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Division of Health Studies

FINAL REPORT

Technical Assistance to the American Samoa Government Department of Health Services Pago Pago, American Samoa

Biologic Indicators of Exposure to Heavy Metals in Fish Consumers, American Samoa

March 1995

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY
ATLANTA, GEORGIA

BIOLOGIC INDICATORS OF EXPOSURE TO HEAVY METALS IN FISH CONSUMERS

TECHNICAL ASSISTANCE TO THE AMERICAN SAMOA GOVERNMENT, DEPARTMENT OF HEALTH SERVICES PAGO PAGO, AMERICAN SAMOA

March 1995

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ABSTRACT

The Agency for Toxic Substances and Disease Registry and the American Samoa Government conducted an exposure study to determine whether residents of American Samoa were exposed to selected metals as a result of eating locally caught fish. Several species of fish from the Pago Pago Harbor area had been found to have elevated metal levels. A cross-sectional biologic indicators of exposure study was conducted among residents living in three villages around Pago Pago Harbor on the main island (Tutuila, n = 103) and three villages on a comparison island (Ta'U, n = 104). Biologic specimens were collected to quantify levels of arsenic, cadmium, chromium, mercury, and nickel in urine, and levels of lead and mercury in blood. A stratified random sample of participants was selected from the Department of Health Services family health records using the following criteria: those eligible had to be 8 through 75 years of age, of American Samoa nationality, and a resident of the village for at least one year before the study. Participants were interviewed in English or Samoan about personal behaviors, occupations, fish consumption, and other factors that might influence exposure to metals.

Geometric mean urine arsenic levels were statistically significantly higher in the total comparison population (94.63 micrograms per gram [μg/g]) than in the target population (47.47 μg/g)($p = 0.001$); the other six analytes were not statistically significantly different. Among all participants 26 through 45 years of age, the geometric means of urine arsenic (80.64 μg/g versus 50.40 μg/g; $p = .057$) and blood mercury (10.10 micrograms per liter [μg/L] versus 6.89 μg/L; $p = .007$) were statistically significantly higher for those with "high fish consumption" levels than for those with "low fish consumption" levels. Of 103 participants surveyed from the target area, 98% (n = 101) reported not having eaten fish caught in inner Pago Pago Harbor where a fish advisory was in effect.

BIOLOGIC INDICATORS OF EXPOSURE TO HEAVY METALS IN FISH CONSUMERS
PAGO PAGO, AMERICAN SAMOA

INTRODUCTION

American Samoa is an unincorporated territory of the United States located in the South Pacific, 3,700 kilometers southwest of Hawaii. The territory, which has a population of approximately 47,000 people, comprises 7 main islands— Tutuila, Aunuu, Ofu, Olosega, Ta'U, Rose, and Swains (Appendix A). Pago Pago Harbor is located on the island of Tutuila. The harbor has been a source of concern because of the accumulation of contaminants from industrial, natural, and military sources. In July 1991, the U.S. Environmental Protection Agency (EPA) reported that elevated levels of various heavy metals and pesticides were found in fish, seawater, and sediment in the inner portion of the harbor. The heavy metals included arsenic, cadmium, chromium, lead, mercury, and nickel. Based on the findings of this report, the American Samoa Government (ASG) issued a health advisory in October 1991, warning residents not to eat fish caught in inner Pago Pago Harbor and to always clean and gut fish (before eating) that were caught in outer Pago Pago Harbor (Appendix B). The advisory was based on concerns about possible adverse health effects resulting from consumption of harbor fish with elevated levels of heavy metals.

On November 27, 1991, the ASG requested technical assistance from the Agency for Toxic Substances and Disease Registry (ATSDR) to determine whether fish contaminated with heavy metals from inner Pago Pago Harbor in American Samoa presented a public health hazard to American Samoans who ate the fish (Appendix C). In response to the request, the Health Investigations Branch (HIB), Division of Health Studies, ATSDR, and the ASG Department of Health Services conducted a study during the summer of 1992.

OBJECTIVES

The objectives of this study were twofold:

1. To determine and compare the levels of arsenic, cadmium, chromium, lead, mercury, and nickel in the urine and blood of residents living near the inner Pago Pago Harbor area with the same analytes found in residents of a comparison population.

2. To determine whether urine and blood analytes within each age group increased as fish consumption increased.

BACKGROUND

In 1990, a pilot study was conducted by the American Samoa Department of Marine and Wildlife Resources (ASDMWR), American Samoa Environmental Protection Agency (ASEPA), and the American Samoa Coastal Management Program (ASCMP) to determine whether toxic chemical compounds could be detected in the marine environment of Pago Pago Harbor and to provide a preliminary assessment of the extent of contamination and the risk to public health. The study reported that elevated levels of various heavy metals and pesticides were found in fish, seawater, and sediment in the inner portion of the harbor (*1*). The heavy metals were arsenic, cadmium, chromium, lead, mercury, and zinc. No point source of hazardous waste was identified as solely responsible for the harbor contamination. However, poor circulation and flushing of the inner harbor, ship traffic and mooring, several industries (tuna canneries, ship cleaning operations, and a power plant with fuel storage facilities), military ships which sank in the harbor during World War II, and naturally occurring metals from the erosion of soils might have contributed to the contamination. Potential consumption of contaminated fish was of greatest concern to the American Samoa authorities because of reports of local residents eating fish from the inner harbor, despite the health advisory.

Presence of Heavy Metals in the Environment

Heavy metals can be found in all parts of the environment, including air, drinking water, rivers, lakes, oceans, soil, plants, and animals. They emerge as trace elements in ocean water, and, therefore, it is difficult to establish accurate concentrations for these metals (*1*). The six metals for which elevated levels were found in the inner harbor water samples are naturally occurring elements in the earth's crust. Metals such as arsenic and mercury can be found in organic or inorganic forms, depending on the elements with which they combine.

Pathways of Exposure and Confounders in Humans

Human exposure to heavy metals can occur through ingestion, inhalation, and dermal contact. Seafood consumption is a primary pathway of human exposure to many toxic metals (*2*). An individual's exposure to metals from seafood is primarily influenced by the amount and type of seafood consumed. Certain species of fish have higher levels of contaminants than other species (*3*). Many potentially confounding factors can also influence metal toxicity, including age, diet, and simultaneous exposure to other metals. Factors such as smoking and alcohol ingestion can also influence metal toxicity. Tobacco smoke contains arsenic, cadmium, and nickel (*4-7*). Alcohol reduces essential nutrient intake, which can affect the absorption and metabolism of a heavy metal. The combination of smoking and alcohol consumption can contribute to increased cadmium and lead levels in adults (*5,8-10*).

Arsenic

Arsenic exists in three common valence states: metalloid (zero oxidation state), arsenite (trivalent state), and arsenate (pentavalent state). With few exceptions, inorganic arsenic is more toxic to humans than organic arsenic (*4*). The toxicity of trivalent arsenite is typically greater than that of pentavalent arsenate, but little is known about the toxicity of zero valent arsenic. Oxidation-reduction reactions result in some interconversion of arsenate to arsenite *in vivo*, and a methylation process representing detoxification occurs in the liver. If the methylating capacity of the liver is exceeded, exposure to excess levels of inorganic arsenic will result in increased toxicity and retention of arsenic in soft tissues. Health effects of arsenic ingestion range from skin abnormalities, nausea, and vomiting to increased liver, bladder, kidney, and lung cancers (*4*).

In the general population, the main route of arsenic exposure is via ingestion of arsenic-containing food and water (*4*). Meat, fish, and poultry account for 80% of dietary arsenic intake. Fish, seafood, and algae also contain high concentrations of arsenic in the forms of arsenobetaine and arsenocholine, sometimes referred to as "fish arsenic." Fish arsenic is apparently not biotransformed *in vivo*, is rapidly excreted unchanged in the urine, and has low toxicity to humans (*4,11-14*). The biologic half-life of ingested fish arsenic is estimated to be less than 20 hours, with total clearance in approximately 48 hours (*4*).

Appendix D, Figure 1, lists the American, Canadian, and Australian suggested provisional weekly intake limits (PWIL) for cadmium, mercury, arsenic, copper, zinc, and lead. Appendix D, Figure 2, compares the acceptable daily intake limits (ADIL) of trace metals in all foods as suggested by the Food and Agricultural Organization and World Health Organization (FAO/WHO) with the mean American daily intake of trace metals reported by the Food and Drug Administration (FDA) (*3*). Clearly, seafood is an important source of overall arsenic exposure in the diet, with mean daily intake from a 15-pound-per-year U.S. catch reported as 82.0 micrograms (μg) (*3*). FDA estimates, based on a 250-g finfish serving, range from 62.5 to 5,157 μg (*3*). The FAO/WHO provisional tolerable weekly limit for arsenic is 182 μg.

Cadmium

Food is the primary source of cadmium exposure for the general population (*5*). Low levels of cadmium are found in basic foodstuffs, especially grains, cereals, and leafy vegetables, which readily absorb cadmium (either naturally occurring or resulting from contaminated soil or groundwater exposure). Cadmium bioaccumulates in the food chain; consequently, ingestion of animal liver and kidneys and some types of fish and shellfish can result in increased exposure (*4*). Typical cadmium concentrations in the flesh of fish from unpolluted waters range from 1 to 100 micrograms per kilogram (μg/kg) for fish flesh and from 70 to 1,200 μg/kg, for shellfish (*3*). The overall seafood-related consumption of cadmium is estimated to be 2 micrograms per day (μg/day), and represents about 6% of the overall dietary exposure estimated from the FDA's total diet program (*3*). Within seafood, cadmium is relatively highly concentrated in molluscan shellfish. For a 250-g fish serving, based on FDA database ranges, intake varies from 0.15 to 157.50 μg. The ADIL for cadmium is 57 to 72 μg (*3*), and the mean daily intake from a 15-pound-per-year U.S. catch estimate is 2.0 μg (Appendix D, Figure 2). Cadmium is eliminated from the body primarily in urine. The rate of urinary excretion is slow; whereas the cadmium concentration in the blood reflects recent exposure, urinary cadmium concentration more closely reflects total body burden. The biologic half-life of cadmium in the body is estimated to be 30 years, and chronic exposure primarily affects the kidneys and skeletal system (*5*).

Chromium

The entry routes of chromium into the human body are inhalation, ingestion, and dermal absorption. The general population is commonly exposed to chromium in soil, food, and water (*15*). In chronic chromium exposure, the respiratory system, kidneys, liver, and skin may be affected. Urinary chromium excretion reflects absorption over the previous 1 or 2 days only. For individuals without excessive exposure to chromium, urinary chromium values are typically less than 10 µg for a 24-hour period (*15*). The overall consumption of chromium from seafood reported by Hall et al. (*3*) appears well below the acceptable daily intake limit of 2.0 µg. The FDA-calculated short-term intake levels range from 87.5 to 5,000 µg for a 250-g fish portion, which is considerably higher (by a factor of 25) than the WHO-estimated safe and daily dietary intake level of 50 to 200 µg; it is unclear whether a rare exposure of this magnitude is problematic (*3*). The mean daily intake from a 15-pound-per-year catch estimate is 3.7 µg, as reported in Appendix D, Figure 2.

Lead

The major sources of lead exposure in the United States (paint, automobile exhaust, food, and water) might also have contributed to exposures in American Samoa. For children, important pathways are ingestion of lead dust and chips from deteriorating lead-painted surfaces, inhalation of lead from automobile emissions, food from lead-soldered cans, and drinking water from lead-soldered plumbing (*8*). In addition to environmental exposures, many occupations, hobbies, and other activities result in potential exposures to high levels of lead and can put an entire family at risk of lead poisoning. Lead-glazed pottery is also a potential source of dietary exposure. The body accumulates lead over a lifetime and releases it slowly, so even small doses over time can cause lead poisoning, affecting primarily the nervous system and blood cells (*8*). Calculated results from Hall et al. (*3*) on intake for a 250-g fish serving (based on ranges of 0.008 to 2.3 parts per million (ppm) in fish from designated databases) of 2.0 to 575.0 µg, exceeded the FAO/WHO acceptable daily intake level of 429 µg by a factor of 1.3 (*3*). The Centers for Disease Control and Prevention (CDC) has established 10 micrograms per deciliter (µg/dL) blood lead as a level of health concern for children (*16*).

Mercury

Mercury exists in three forms: elemental mercury, inorganic mercury salts, and organic mercury. Any mercury compound released into the environment becomes available for methylation to methylmercury by organisms indigenous to soils and waters. Weathering of mercury-bearing rock and industrial effluent are the major sources of mercury contamination in water (*17*). Methylmercury in surface waters accumulates in fish and other aquatic organisms, and fish at the top of the food chain typically biomagnify mercury up to 100,000 times the concentration in surrounding waters. In the general population, diet is the major source of methylmercury exposure, primarily through fish consumption (*17*). A study of freshwater and saltwater species by Cappon and Smith found an average of 85.2% of total mercury to be in the methylated form in the edible muscle of freshwater fish (*18*). About 90% of methylmercury is found in red blood cells; the major route of excretion is through the bile into the feces, with urinary excretion accounting for the remaining 10%.

In adults, the background mercury concentration is generally <1.5 μg/dL in blood and <20 micrograms per liter (μg/L) in urine (*17*). The estimated population average consumption of mercury from seafood is about 2.1 μg/day, which represents over half of the mercury estimated to be in the diet as a whole for 25- to 50-year-old males who were found to have the highest daily mercury consumption in the FDA Total Daily Diet Study (*3*).

Site Characterization

Fish

Fish tissue results from the "Preliminary Toxicity Study of Water, Sediment, and Fish Tissues from inner Pago Pago Harbor in American Samoa" conducted in July 1991 are presented in Appendix E. The results displayed a wide range of concentrations for each of the metals tested. For most metals, the mean concentration in liver tissues was higher than the mean concentration in flesh. Arsenic, mercury, and zinc were particularly concentrated in the liver (factors between 5 and 10), with copper and lead less so (factors of 3). Tissue concentrations were well below sediment concentrations for each metal except mercury. The mean mercury concentration in muscle tissues (all fishes) equaled the baseline wet sediment concentration of 0.03 milligrams per kilogram (mg/kg), and mean mercury concentration in liver tissue was 4.5 times greater (0.14 mg/kg).

The primary fish species tested in Pago Pago Harbor were mullets (representing detritivores, which eat sea matter), surgeon fishes (representing herbivores, which eat plants), and jacks (representing carnivores, which eat fish). Statistically significant differences between herbivores, detritivores, and carnivores are not apparent. However, the mean metals concentrations for mullet flesh were, for all metals except mercury, greater than the means for all fish combined. Mullet liver tissue concentrations exceeded the overall means for copper and lead.

Seawater

Seawater samples were collected from just below the surface of the inner Pago Pago Harbor in April 1990, and at the same site in October 1991. Measuring and analyzing heavy metal concentrations in water from Pago Pago Harbor were difficult because of the naturally occurring presence of heavy metals from the erosion of volcanic soils. Arsenic, cadmium, chromium, nickel, and silver levels in seawater were below detection levels. Both copper (0.10 ppm) and zinc (0.10 ppm) exceeded the EPA criterion value for seawater (0.0029 ppm), but it was difficult to characterize the extent of the pollution problems in the harbor because so few samples were taken (*1*).

Sediment

In an EPA-commissioned study, sediment samples were collected from six sites in Pago Pago Harbor on April 19, 1990. Results of the study *(1)* revealed that harbor sediments were a mixture of particles from the catchment basin, marine limestones, and biologic (organic) sources. As in most coastal waters, concentrations were higher from runoff, settlement of windblown solids, and human activity. The report *(1)* stated that harbor sediments were moderately to heavily polluted with arsenic, chromium, copper, nickel, and zinc. However, sediment values from Hawaiian marine and estuarine environment areas where pollution influences are thought to be slight or not present show similar high levels of arsenic, chromium, copper, nickel, mercury, and zinc (*1*).

METHODS

Rationale for Study Design

The overall objective of the study was to determine if residents who lived near the inner Pago Pago Harbor (target area) had higher biologic levels in blood or urine of selected heavy metals (arsenic, cadmium, chromium, lead, mercury, and nickel) than residents of a comparison area. In addition, the effects of demographic, behavioral, and other potentially confounding factors on heavy metal exposure were examined.

A cross-sectional biologic indicators of metal exposure study was conducted among residents living in three villages around Pago Pago Harbor on the main island (Tutuila, $n = 103$) and three villages on a comparison island (Ta'U, $n = 104$). The same eligibility criteria were used to select participants from the target and comparison populations. A stratified random sample of participants was selected from the Department of Health Services family health records using the following criteria: those eligible had to be from 8 through 75 years of age, be of American Samoa nationality, and be a resident of the village for at least one year before the study. Participants were interviewed in English or Samoan about personal behaviors, occupations, fish consumption, and other factors that might influence exposure to metals. Biologic specimens were collected to quantify levels of arsenic, cadmium, chromium, mercury, and nickel in urine, and levels of lead and mercury in blood.

Community Involvement and Notification

To enhance community awareness and increase participation, the Governor of American Samoa issued an executive order endorsing the study. Media coverage included newspaper articles about the study and television interviews of ATSDR, ASDHS, and EPA staff members. Publicity stressed the voluntary nature of participation, the public health significance of the study, and the time period for participation. A meeting was held with government and community leaders during the first week to ensure that the interests and concerns of the community were adequately addressed. The meeting facilitated communication between local officials, residents, and the ATSDR and ASGDHS staff.

ATSDR contracted with a retired American Samoan physician to assist with coordinating and conducting all phases of the study. He served as a consultant, interpreter, and liaison with government and community leaders. Public health nurses responsible for the six study villages administered and translated questionnaire and specimen collection information in English or Samoan.

Selection of Target Area

The target study population was comprised of residents of the villages of Pago Pago, Fagatogo, and Atu'U. These three villages all share the shoreline of the inner harbor, are less than a mile apart, and are located where residents are most likely to catch and consume contaminated fish. Fagatogo is the largest town and borders the south side of Pago Pago Harbor. The village of Pago Pago is at the west end of the harbor. The third village, Atu'U, is located on the north side of the harbor.

Selection of Comparison Area

Ta'U is an island of the territory, located 60 miles east of Tutuila. Residents of Ta'U were selected as the comparison group because they presumably were not eating fish from contaminated waters and were not importing fish from inner Pago Pago Harbor. They were considered to have an education level and socioeconomic status similar to that of residents of the Pago Pago area, based on discussions with staff of the ASG Department of Health Services.

Participant Selection

In American Samoa, free universal health care is provided to all American Samoa residents. Records of those eligible for this service are maintained in the form of family folders. For this study, these folders provided the most accessible and reliable demographic data available on households in the target and comparison areas. Each family folder contained individually numbered medical records for each household member. A representative sample of American Samoan residents who lived in the target or comparison areas for at least one year was selected from the family folders using a stratified random selection process. Family folders from the target population were maintained in the Lyndon B. Johnson (LBJ) Tropical Medical Hospital, Department of Health Services, Public Health Division. Family folders from the comparison population were maintained in the Ta'U village dispensary.

Participant selection was structured to collect interview data and biologic specimens from a sample of eligible residents 8 through 75 years of age. Individuals, not families, were the sampling unit. Potential participants were randomly selected using family folders with medical identification numbers and a random number table. The three age groups of eligible residents selected for participation were 8 through 25 years of age, 26 through 45 years of age, and 46 through 75 years of age. The three age strata were selected primarily to ensure the representation of various ages in the sample.

Sample Size Calculations

The number of participants required for an adequate sample size in each age group was estimated using the means and standard deviations of exposure data from similar ATSDR-supported studies conducted in Park City, Utah, in October 1987 (*19*) and Leadville, Colorado, in September 1987 (*20*). Appendix F lists sample size criteria for the two studies that estimated sample sizes to detect a difference of 50%, assuming an alpha level of 0.05, and equal sample sizes in the target and comparison areas with a statistical power of 0.80. From these estimates, a total of 216 participants were recruited into the study. For American Samoa, the participants were stratified by age group, sex, village, and island of residence.

Sampling Algorithm

A random sample of residents, frequency matched on age and sex, was drawn from the target area and the comparison area using the individual medical records from the family folders. Selected residents who were unlocatable or who declined to participate were replaced with other randomly selected individuals.

Data Collection

Location of Interviews and Blood and Urine Collection

In the target area, interview data and specimens were collected in the homes of three village chiefs (Pulenu'us), at the LBJ Tropical Medicine Hospital, and in the homes of participants. In the comparison area, interview data and specimens were collected at the Ta'U dispensary, the Faleasao elementary school, and the home of the Pulenu'u in Fitiuta.

Interviews

The Pulenu'u and public health nurse contacted the individuals who had been randomly selected and invited them to participate in the study. If a selected individual was unable to participate on the day of data collection, the study phlebotomist and Samoan public health nurse made at least five attempts to contact that person at home or work to obtain the biologic specimens and administer the questionnaire. If contact with the individual was not made, another randomly selected individual of the same age group, sex, and village category was invited to participate.

Informed Consent

At the onset of each interview, the consent of the participant was requested using the form entitled "Participant Consent for Interview, Blood and Urine Collection" (Appendix G). Parents or guardians were asked to provide consent for interviewing and testing minor children (under 18 years of age). In addition to parental consent, children aged 8 through 17 years were asked to consent to testing as well. A separate consent form was used for each household member who participated. An English or Samoan copy (as required) of the consent form was given to each participant for his or her own records. All but one of the adult participants responded for themselves during the interview; an adult who had Down's syndrome requested assistance from his guardian in completing the study questionnaire. With parental or guardian approval, participants 16 or 17 years of age could be interviewed without a parent or guardian present. Participants 12 through 15 years of age could answer questions for themselves, but had to be interviewed with a parent or guardian present. Parents or guardians answered questions for children under the age of 12 years.

Questionnaire

Interviews were conducted using a structured questionnaire similar to that used by ATSDR in several previous surveys of fish consumers. The questionnaire was divided into a household section, demographics section, residence section, tobacco and alcohol use section, female reproductive history section, occupation section, and dietary section (Appendix H). The ASDMWR comparison of shoreline catches by species (Appendix I) was used to develop the study questions for species of fish eaten.

Both English and Samoan versions of the questionnaire were available to participants. The questionnaire was translated into Samoan and administered to those who spoke only Samoan or who felt more comfortable in conducting the interview in the Samoan language. The questionnaire translation process included two steps. The first step entailed one translator translating the original written document from the English version into the Samoan version. The second step included a second translator translating the questionnaire back from Samoan to English. This quality control process was used to ensure that the document was translated correctly.

Interviewers

To maintain the integrity of the information obtained in personal interviews, all interviewers received instruction in the proper administration of the questionnaire. Those interviewers who were bilingual participated in a second training session for the Samoan questionnaire. The interviewer training covered general interviewing techniques, specific instructions on how to avoid introducing bias in the interview, and question-by-question instructions. Interviewers were observed role-playing before beginning the actual survey. Completed questionnaires were reviewed daily by the investigators to ensure accuracy in data recording.

Biologic Specimens

Specimens were collected to quantify exposure to arsenic, cadmium, chromium, mercury, and nickel in urine, and exposure to lead and mercury in blood. A standard protocol was used for laboratory analysis (Appendix J). Urine and blood specimens were collected, processed, and shipped to the CDC National Center for Environmental Health (NCEH) laboratory for analysis. Because urine levels of heavy metals are often transient, an effort was made to collect first morning voided urine. Participants were asked to refrain from eating fish for 2 days before specimen collection. If a participant ate fish within the 48 hours before specimen collection, a follow-up appointment was made for the individual to return or the phlebotomist visited the home to collect the specimen. If it was impossible to obtain the specimen at another time, the specimen was collected and it was noted on the questionnaire that the participant had eaten fish within the previous 48 hours.

Methods of Collection

Specimens were collected at various locations during the study according to established procedures. Special care was taken to prevent the contamination of specimens with the analytes of interest. Metals-screened lots of collection materials, including vials, vacutainers, and collection cups, were sent from the NCEH laboratory.

A CDC medical technician (phlebotomist) drew venous blood from each participant. At the time of the interview, a sterile, plastic 250-milliliter (mL) urine collection cup was prepared and given to the participant with instructions for its use. The study participant was asked to remove the cup and cap from the plastic wrapping without dislodging the cap or touching the inside of the container or cap. The parent or guardian of each child participant assisted the child when necessary. All specimens were collected, processed, and shipped according to laboratory procedures established by NCEH for metal analysis.

Chain of Custody

Established documentation methods were used to preserve the chain of custody and safeguard against tampering with samples or records. These methods included using a shipping list with dates of collection and participant identification numbers. Each specimen was assigned a unique identification number to allow appropriate identification. The numbering system uniquely described the study, the person, the specimen matrix, and the aliquot number. The identification number for each participant was placed on the specimen cup, blood collection tube, questionnaire, consent form, and folder. CDC-approved laboratory transfer sheets were used. These sheets contained the signatures of the personnel who received the specimens and the date of receipt, how much of the specimen was used, and whether the specimen was compromised in any way in the laboratory. Any departures from the collection, storage, or shipping protocol were noted and reviewed by a CDC laboratory technician. This provision allowed for any compromised specimen to be reported with the analytical results, to be reported with additional caveats, or not to be reported at all.

Laboratory Methods and Quality Control

All laboratory analyses were conducted with established procedures for quality control. The report of laboratory data has undergone an internal review by scientific, administrative, and statistical staff of the NCEH Division of Environmental Health Laboratory Sciences.

Privacy

All study records were maintained in compliance with the Privacy Act of 1974. The results discussed in this report do not contain laboratory results or findings associated with any individual participant. To ensure privacy and confidentiality, questionnaire pages with personal identifiers were stored separately from the rest of the questionnaire. Only individual identification numbers appeared on all forms. All records were kept in locked file cabinets or drawers in a locked office at the LBJ Tropical Medical Hospital.

Individual Notification

Individual letters for study participants containing laboratory results were reported by ATSDR to the ASG Department of Health Services. The Department of Health Services mailed the letters of results, interpretations, and recommendations to the parents or guardians of the participants. These letters included the telephone number and address of a contact person at the Department of Health Services prepared to respond to participants' questions and recommend medical followup when necessary.

Data Entry

All questionnaires were reviewed daily for missing data and ambiguous responses, and again before the data were coded. Individual interviewers were contacted immediately by the study's investigators after each interview in an effort to obtain missing data, if necessary. The data were double entered into a computer and verified against the original document to check for data entry errors. Questionnaire data files were merged with laboratory data files to form a single database.

Data Transformation

Urine analyte results vary depending on urinary concentrations. Therefore, all urine arsenic, cadmium, chromium, mercury, and nickel levels were adjusted to account for urinary concentration using urine creatinine in the following formula:

$$\text{UrCdCr} = \frac{\text{UrCd } \mu\text{g/L}}{\text{UrCr } \mu\text{g/L}} \times 100 \ (\mu\text{g/g of creatinine})$$

where:

UrCdCr = Urine cadmium adjusted to urine creatinine
UrCd = Urine cadmium uncorrected
UrCr = Urine creatinine

The distribution of most biologic measurements has a tendency to be log normal. Since the statistical comparison of sample means requires the assumption of normal distributions, it was necessary to transform the data to fulfill this assumption. The logarithmic transformation was used to approximate a normal distribution for these data. The resulting distributions were then tested for normality before the analyses were conducted.

Data Analysis

The analysis of questionnaire and laboratory data progressed from descriptive analyses to multivariate techniques. The distribution of laboratory values was examined for normality, and the values were log transformed accordingly. The results of the study were analyzed in three phases. Initially, the distribution for the entire study population was characterized for the target and comparison groups. The second stage of the analysis compared each variable independently for the target and comparison groups to determine whether there was a statistically significant difference between the two groups. Variables were also analyzed to determine their association with the biologic measurements of a specific metal. This stage of the analysis also used stratification to determine possible confounding or effect modification between variables.

The third phase of the analysis involved constructing linear and logistic regression models to evaluate the associations between metal exposure, area of residence, and seafood consumption while simultaneously controlling the effects of multiple confounders or effect modifiers. This combination of analytic strategies provided a more comprehensive analysis of the data than simply relying on multivariate modeling. These methods of analysis are described in the following sections.

Univariate Analysis

Univariate analyses generated descriptive statistics to characterize data in both the target and comparison groups. More specifically, these analyses described the distributions of biologic exposure measures, environmental samples, and questionnaire responses. The mean, standard deviation, and range statistics were used to describe the distribution of continuous variables. Frequency and percentile statistics were used to characterize distributions of categorical and ordinal variables.

Bivariate Analysis

Bivariate analyses provided a crude measure of association between outcome measures and exposure measures. These analyses involved the two-sample Student's t-test, calculation of odds ratios (ORs), correlation coefficients between continuous variables, and simple linear regression. The t-test was used to evaluate the statistical significance of the association of independent variables, including the target and comparison areas of residence, with mean metal levels. The t-test compared the mean value and distribution of each exposure variable category with the mean value of the reference category of the same variable.

ORs with 95% confidence intervals (CIs) were calculated for 11 questionnaire variables, with each analyte dichotomized into high and low levels. The following analytes were dichotomized: urine arsenic at 80 μg/g, urine cadmium at 2 μg/g, urine chromium at 2 μg/g, urine mercury at 10 μg/g, urine nickel at 5 μg/g, blood lead at 10 μg/dL, and blood mercury at 10 μg/L. The rationale for dichotomizing at these levels was based on established reference intervals for the analytes or on experience with previous studies conducted by ATSDR (*21-23*). Correlation coefficients and correlation matrices were calculated to assess the strength of associations among the biologic measures (blood and urine), and continuous measures of exposure (for eating fish and tobacco use). The associations for categorical and ordinal data were also examined using ORs and chi-square statistics.

ORs and 95% CIs were calculated for the following 11 variables: (1) area of residence (target versus comparison), (2) smoked more than 100 cigarettes in entire life, (3) currently drink at least one drink per week, (4) high versus low fish consumption, (5) knowledge of health advisory, (6) amount or types of fish eaten from the inner harbor, (7) concern about fish contamination in inner harbor, (8) total household income less than or equal to $10,000 per year, (9) high school graduate, (10) use public water for drinking at home, and (11) use public water for cooking at home. A variable, "fish consumption," was created by dichotomizing the "fish intake" variable at the median.

Multivariate Analysis

On the basis of the results of the first two phases of analysis, variables were selected for inclusion in the multivariate analyses. The multivariate models applied to the data were multiple linear regression and logistic regression. The multivariate modeling methods described in this section relied heavily on the modeling strategies described by Kleinbaum, Kupper, and Muller (*24*), and were applicable to both linear and logistic regression.

The modeling strategy for these data involved three stages. The first stage involved selection of the exposure variables and covariates for inclusion in the model. These variables were determined based on the objectives of the study, a clinical or biologic rationale, or the results of the preliminary stages of the data analysis. Covariates were included in the model building process if their significance tests for association with the dependent variable were less than $p = 0.10$ during the first two stages of analysis. The significance level of 0.10 was used to initially consider variables of borderline significance. The dependent variable for all of the models was a biologic analyte (arsenic, cadmium, or mercury). The independent variables of interest for this study were one or more measures of environmental exposure, using either area of residence or consumption of fish. The fish consumption variable represented the product of the portion of fish eaten in an average meal and the number of fish meals eaten per week. Other variables were included in the model according to their potential to act as confounders or effect modifiers, or because they had been shown in previous investigations to be associated with the biologic analytes.

The second stage of model building assessed effect modification. In this stage, product terms representing a combination of the exposure variable and certain covariates were included in the model and then gradually eliminated until only statistically significant interaction terms remained. The third stage in the modeling strategy assessed confounding of the exposure and outcome association for all first-order covariates in the model, except those showing effect modification. Each covariate was removed from the model, and the effect on the beta coefficient of the exposure variable was assessed. Those covariates that did not appreciably alter the association were not considered confounders.

Covariates were also retained in the final model if they improved the overall precision of the model. The statistical significance of each variable was determined by the partial F-test for linear regression and by the log likelihood test for logistic regression. Those variables that were not effect modifiers or confounders and did not statistically significantly add to the predictive value of the model and were not of interest to the investigators were eliminated. This modeling strategy permitted a valid estimate of the association between outcome and exposure of interest, while controlling for potential confounders and examining effect modifiers.

Linear regression models used log-transformed laboratory data for urine arsenic and cadmium and blood mercury as the dependent or outcome variable. After transformation, urine nickel was still not sufficiently normally distributed and, therefore, was not included in linear regression modeling. Variables were retained in the model if they were associated with the dependent variable at the $p = 0.10$ level. Variables for age and sex were also included. The exposure variables for area of residence (target versus comparison) and fish consumption were included in every model. Product terms of the exposure variables and covariates of interest were evaluated for effect modification. Terms that were not statistically significant at the $p \leq 0.10$ level or were not of clinical interest to the study were not retained in the models. All variables were coded as yes or no, except age, which was left as a continuous variable. For logistic regression, the continuous biologic data were dichotomized. Logistic regression allowed the associations between the dichotomized exposure and outcome variables to be expressed as ORs with 95% CIs.

RESULTS

The results from this investigation are presented in the following sections. The first section includes participation rates for the target and comparison groups. The second section includes demographic and fish consumption characteristics for the target and comparison study groups. The third section presents the laboratory findings for each respective analyte. This section also reports each analyte level for the species of fish consumed as the exposure variable of interest. The fourth and final section presents the modeling results.

Urine test results are reported as corrected (μg/g of creatinine) values to avoid effects due to variation in urine output. The statistically significant findings are presented for the target and comparison study groups. The distributions of urine (μg/g) and blood analyte (μg/dL or

μg/L) results are presented for each of the three age groups: 8 though 25 years of age, 26 through 45 years of age, and 46 to 75 years of age.

Thirty arithmetic means, geometric means, standard deviations, ranges, and t-tests were used to describe all five urine analytes (arsenic, cadmium, chromium, mercury, and nickel) between the target and comparison groups. Twelve arithmetic means, geometric means, standard deviations, ranges, and t-tests were used to describe and compare both blood analyte (mercury and lead) results between the target and comparison groups.

The data analysis process involved the calculation of a large number of statistical tests of significance. A total of 33 ORs with 95% CIs were calculated for each analyte with 11 questionnaire variables selected for all 3 age groups. Approximately 60 t-tests were computed for each analyte, including comparison of area of residence and possible confounding variables for each age group.

Participation

A total of 468 residents were selected to participate in the study (Table 1). Of the 468 residents, 207 (44%) were interviewed, and 206 provided blood and urine samples. A similar proportion of subjects was interviewed for the target (42%) and the comparison (46%) populations. There were no refusals in the target area and only two refusals (1%) in the comparison area. A high percentage (58% target versus 53% comparison) of residents of both islands could not be contacted to participate in the study. Many families were reportedly traveling to other villages or vacationing. However, similar proportions of participants were selected and interviewed from each of the six villages (Table 2).

Demographic and Other Characteristics

Table 3 shows a comparison of the two populations on demographic factors. A higher proportion of participants in the target group had a total family income of at least $10,000 per year than in the comparison group (42% versus 23%), and a higher proportion of target group participants graduated from high school than did comparison group participants (58% versus 38%).

Fish consumption was not statistically significantly different between the two groups ($p = .73$). Of 204 respondents, 32 (16%) reported that they ate no fish during the month preceding the survey, and 31 (15%) reported eating less than one fish meal a week (Table 4). A trend of increased fish consumption was seen with age when comparing low versus high fish consumption levels in the target and comparison groups (Table 5). Of 192 participants who responded to these questions, 88 (91%) in the target group and 89 (94%) in the comparison group reported their families usually gutted and cleaned fish before eating them. As expected, a statistically significantly higher ($p < .01$) proportion of participants in the target area knew about the health advisory (77% versus 55%), were concerned about contamination in Pago Pago

Harbor (82% versus 61%), and changed their fishing or eating habits from Pago Pago Harbor (54% versus 33%), than did participants from the comparison group.

Analyte Results by Study Area

The urine analytes corrected for creatinine were compared between the target and comparison groups. For all ages combined, the geometric mean urine arsenic level was statistically significantly higher in the comparison group (94.63 μg/g versus 47.47 μg/g; $p = 0.001$) than in the target group; the other four urine analytes were not statistically significantly different between the target and comparison groups (Table 6A). The blood lead and mercury levels were not statistically significantly different between the target and comparison groups (Table 6B). In the comparison group, 114 (64%) participants reported they ate fish within 48 hours of specimen collection, in contrast to 63 (36%) in the target group.

Analyte Results by Age Group

Statistically significant differences were identified for comparisons of urine analytes by age group for both the target and comparison populations (Table 7). Geometric mean urine arsenic levels were statistically significantly higher among participants 8 through 25 years of age and 46 through 75 years of age in the comparison group than in those age groups in the target group. However, geometric mean urine mercury levels were statistically significantly higher only among participants 26 through 45 years of age in the target group when compared with the same age group in the comparison group. None of the other urine or blood analyte levels were statistically significantly different between the target and comparison groups by age group.

Analyte Results by Fish Consumption

Statistically significant differences were also identified for urine and blood analytes among participants with high and low levels of consumption (Tables 8A through 8C). Among all participants 26 through 45 years of age, the geometric mean urine arsenic level and geometric mean blood mercury level were statistically significantly higher among those with high fish consumption levels than among those with low fish consumption levels. The other five analytes were not statistically significantly different in this age group, and none of the seven analytes were statistically significantly different in the younger or older age groups.

Urine Arsenic Analysis

Among target and comparison area participants who ate fish within 48 hours of urine collection, a higher proportion had elevated levels of urine arsenic than participants who did not eat fish. The geometric mean urine arsenic level for participants who ate fish within 48 hours of urine collection was compared for the target and comparison groups. For all ages combined, the geometric mean urine arsenic level was statistically significantly higher in the target group (119.58 μg/g versus 40.53 μg/g; $p = <.001$) and higher in the comparison group, but the increase was not statistically significant (109.73 μg/g versus 85.46 μg/g; $p = 0.19$) (Table 9).

Within each age group, the comparison area participants had higher levels of urine arsenic (Table 7). The geometric mean urine arsenic levels were compared for participants who did and did not have reported risk factors for arsenic exposure. All variables that showed a statistically significant difference ($p \leq 0.10$) in mean urine arsenic levels are presented in Table 10. Variables found to be associated with higher urinary arsenic levels were living in a house built before 1976, having less than a high school education, having a high level of fish consumption, metal exposure related hobbies within last 90 days, family occupations, household income of less than or equal to $10,000 per year, and catching fish the month before the survey. Low education levels were associated with higher urine arsenic levels in two age groups.

ORs and 95% CIs were computed for selected variables and urine arsenic levels were dichotomized at 80 μg/g (Table 11). Participants 8 through 25 years of age who were concerned about fish contamination in inner Pago Pago Harbor were more than 4.5 times as likely to have a urine arsenic level at ≥ 80 μg/g compared with those who were not concerned. For participants 8 through 25 years old, the elevated urine arsenic levels were associated with residence in the comparison area. There were no statistically significantly elevated ORs for high fish consumption in any age group.

Urine Cadmium Analysis

Very few participants (4% of 206) had urine cadmium levels >2 μg/g. Within each age group, the comparison area participants had higher levels of urine cadmium. Only 15% of comparison area participants 46 through 75 years of age had levels >2 μg/g. In contrast, only 4% and 6% of the target area participants 26 through 45 and 46 through 75 years of age, respectively, had levels >2 μg/g.

The geometric mean urine cadmium levels were compared for participants who did and did not have reported risk factors for cadmium exposure. All variables that showed a statistically significant difference ($p \leq 0.10$) in mean urine cadmium levels are presented in Table 12. Variables found to be associated with higher urinary cadmium levels were drinking alcohol at least once a week, living in a house built before 1976, eating fish, having a household income of less than or equal to $10,000 per year, and having less than a high school education. There were no trends with urine cadmium for any exposure variable across the age groups. However, participants 8 through 25 years of age who drank less than one drink of alcohol per week had statistically significantly higher urine cadmium levels than participants who reported they drank at least one drink per week. The number of participants in each age group with urine cadmium results ≥2 μg/g was too small to examine the association of urine cadmium levels with exposure variables of interest by using contingency tables and ORs.

Urine Chromium Analysis

Very few participants (2% of 206) had urine chromium levels ≥2 μg/g. Within each age group, the target area participants had higher levels of urine chromium.

The geometric mean urine chromium levels were compared for participants who did and did not have reported risk factors for chromium exposure. No variables showed a statistically significant difference at the ≥2 μg/g mean urine chromium level. The number of participants in each age group with results ≥2 μg/g was also too small to examine the association of urine chromium levels with exposure variables of interest by using contingency tables and ORs.

Urine Mercury Analysis

Within each age group, the target area participants had higher levels of urine mercury. A higher proportion of target area participants had urine mercury levels ≥ 10 μg/g in the two older age groups than the comparison area (Table 13).

Geometric mean urine mercury levels were compared for participants who did and did not have reported risk factors for mercury exposure. Variables found to be associated with higher urinary mercury levels were working on a job with metal exposure in last 90 days, family member working on a job in last 90 days, and family member working in a fish cannery. There were no consistent associations of urine mercury levels with any exposure variable across the three age groups. The number of participants in each age group with results ≥10 μg/g was too small to examine the association of urine mercury levels with exposure variables of interest by using contingency tables and ORs.

Urine Nickel Analysis

Few participants (6% of 206) had urine nickel levels ≥5 μg/g. Target area participants had a higher geometric mean level of urine nickel only in participants 26 through 45 years of age.

Geometric mean urine nickel levels were compared for participants who did and did not have reported risk factors for nickel exposure. All variables that showed a statistically significant difference ($p \leq 0.10$) in mean urine nickel levels are presented in Table 14. Variables found to be associated with higher urinary nickel levels were smoking (packyears), having less than a high school education, and catching fish the month before the survey.

There were no consistent associations between urine nickel levels and any exposure variable in any of the three age groups. However, cigarette smoking was associated with lower urine nickel levels. Participants with zero packyears of smoking exposure had statistically significantly higher urine nickel levels (1.70 μg/g) compared with those with "1-20 packyears" of smoking (0.86 μg/g). The number of participants in each age group with levels ≥5 μg/g was too small to examine the association of urine nickel levels with exposure variables of interest by using contingency tables and ORs.

Blood Lead Analysis

Few participants (4% of 206) had blood lead levels ≥10 μg/dL. When a level of ≥10 μg/g was used, a slightly higher proportion (5%) of target area participants was identified when compared with comparison area participants (4%).

Geometric mean blood lead levels were compared for participants who did and did not have reported risk factors for lead exposure. Variables found to be associated with higher blood lead levels were living in a house built before 1976, packyears of smoking, caught fish last month, individual's hobbies with metal exposure in last 90 days, and family member with hobbies with metal exposure in last 90 days. Participants 26 years of age and older with lead-related hobbies had statistically significantly higher blood lead levels than those who did not have such hobbies. The number of participants in each group with results ≥10 μg/g was too small to examine the association of blood lead levels with exposure variables of interest by using contingency tables and ORs.

Blood Mercury Analysis

Within each age group, a higher proportion of target area participants had levels of blood mercury ≥10 μg/L (Table 15). Higher proportions were noted in each age group from youngest to oldest (6%, 36%, and 68%, respectively). The comparison area proportions increased with age from youngest to oldest and were lower than the target population in the youngest and oldest age groups (3%, 39%, and 48%, respectively).

Geometric mean blood mercury levels were compared for participants who did and did not have reported risk factors for mercury exposure. Two personal behaviors were associated with higher blood mercury exposure levels in the target area than in the comparison area. The first personal behavior, fish consumption, was examined in the target and comparison populations by comparing the means for the following two variables: (1) "ate fish" (9.12 μg/L versus 6.05 μg/L), and (2) "high fish consumption" (10.07 μg/L versus 6.89 μg/L). Participants 8 through 25 years of age with 1 to 20 packyears of smoking (5.75 μg/L) had statistically significantly higher ($p = 0.013$) blood mercury levels than participants with zero packyears of smoking (3.39 μg/L). Participants 8 to 25 years of age with 21 to 40 packyears of smoking (8.94 μg/L) also had statistically significantly higher ($p = 0.002$) blood mercury levels than those with zero packyears of smoking.

Other variables found to be associated with higher blood mercury levels were whether the participant had caught fish last month, ever worked in a fish cannery, family member with hobbies with metal exposure in the last 90 days, less than a high school education, ever smoked more than 100 cigarettes in life, a job with metal exposure in last 90 days, and a total household income less $10,000 per year. However, none of these findings were consistent across age groups.

ORs and 95% CIs were computed for selected variables and blood mercury levels <10 μg/L (Table 16). The highest OR was associated with "high fish consumption" for participants 26 to 45 years of age (OR = 6.23, 95% CI = 1.62-26.38). There were at least two instances in which the OR was statistically significantly <1. For participants 8 to 25 years of age, elevated blood mercury levels were statistically significantly associated with a total household income less than or equal to $10,000 per year (OR = 0.12) and less than a high school education (OR = 0.10). There was not a consistent association between alcohol intake and blood mercury levels across age groups. There were no statistically significantly elevated ORs for elevated levels of blood mercury in participants 46 through 75 years of age. Since so few participants in this age group had blood mercury levels >10 μg/L, many of the ORs are either not presented or are imprecise.

Urine and Blood Analyte Results by Fish Species

Certain fish types were statistically significantly associated with higher blood and urine analyte levels than other fish groups. The following results summarize the statistically significant higher mean levels of urine and blood analyte results for consuming selected fish:

1. Eating *sturgeon fish* was statistically significant for urine arsenic and cadmium ($p = 0.073$ and $p = 0.096$, respectively).

2. Eating *jack* was statistically significant for urine arsenic, chromium, and mercury ($p = 0.005$, $p = 0.039$, and $p = 0.027$, respectively).

3. Eating *grouper* was statistically significant for urine arsenic, chromium, and blood lead ($p = 0.016$, $p = 0.089$, and $p = 0.089$, respectively).

4. Eating *snapper* was statistically significant for urine arsenic, cadmium, mercury, and blood mercury ($p = 0.067$, $p = 0.007$, $p = 0.016$, and $p = 0.002$, respectively).

5. Eating *squirrel fish* was statistically significant for urine arsenic and blood mercury ($p = 0.037$ and $p = 0.083$, respectively).

6. Eating *mullet* was statistically significant for urine cadmium and blood mercury ($p = 0.088$ and $p = 0.099$, respectively).

7. Eating *parrot fish* was statistically significant for blood lead ($p = 0.050$).

8. Eating *canned fish* was statistically significant for urine cadmium ($p = 0.044$).

Modeling Results

Urine Arsenic

The urine arsenic linear regression model for participants 8 through 75 years of age is shown in Table 17A. Living in the target area was statistically significantly associated with lower urine arsenic levels. However, fish intake was ($p < 0.001$) associated with higher urine arsenic levels. Other variables positively associated with higher urine arsenic levels were age, having a job with metal exposure within the last 90 days, and catching fish. Having at least a high school education was associated with lower urine arsenic levels. Variables representing fish species by class (carnivore or herbivore) were then added to the linear model for urine arsenic. Neither of these variables was statistically significantly associated with urine arsenic.

The results of the linear regression model for urine arsenic were used to construct a logistic regression model. For the logistic model, the dependent variable was urine arsenic level, which had been dichotomized into <80 μg/g and ≥80 μg/g. The urine arsenic logistic regression model for participants 8 through 75 years of age is shown in Table 17B. Residence in the target area was not statistically significantly associated with having a urine arsenic level ≥80 μg/g (OR = 0.58, 95% CI = 0.43 - 1.06) after controlling for other variables in the model. ORs were elevated, although not statistically significantly, for fish intake and catching fish.

Blood Mercury

The blood mercury linear regression model for participants 8 through 75 years of age is shown in Table 18A. Living in the target area was not statistically significantly associated with blood mercury after controlling for all other variables in the model. Another exposure variable, fish intake, however, was a statistically significant predictor of blood mercury after controlling for other variables in the model. Variables representing fish species by class (carnivore or herbivore) were then added to the linear model for blood mercury. Neither of these variables was statistically significantly associated with blood mercury.

The results of the linear regression model for blood mercury were used to construct a logistic regression model. For the model, the dependent variable was blood mercury level, which had been dichotomized at <10 μg/L and ≥10 μg/L. The blood mercury logistic regression model is shown in Table 18B. Residence in the target area was associated, although not statistically significantly, with having a blood mercury level ≥10 μg/L (OR = 1.84, 95% CI = 0.84-4.02) after controlling for other variables in the model. Participants with higher than the median level of fish consumption also had a greater chance of having a blood mercury level ≥10 μg/L, although the estimate was imprecise.

Urine Cadmium

A reduced linear regression model for urine cadmium is shown in Table 19. Living in the comparison area was statistically significantly ($p < 0.004$) associated with higher urine cadmium levels after controlling for all other variables in the model. Fish intake was not statistically significantly ($p < 0.263$) associated with urine cadmium levels. Cadmium levels were also associated with age and packyears of smoking. Variables representing fish species by class (carnivore or herbivore) were also added to the regression model for urine cadmium. Neither of these variables was a statistically significant predictor of urine cadmium levels.

Models were constructed for all of the analytes by linear regression to determine what percentage of the variability could be accounted for by the independent variables. Age accounted for the greatest proportion of the variability for cadmium (32% of 36%) and blood mercury (28% of 45%). Age also made up 9% of the 25% accounted for in the urinary arsenic model. Fish intake accounted for only 5% for arsenic, 3% for mercury, and 0.5% for cadmium. Area of residence accounted for 11% of the arsenic variability, 3% of the cadmium variability, and 0% of the mercury variability.

Results for two target area participants who reportedly ate fish caught in inner Pago Pago Harbor and for four target area participants who reportedly ate fish from the outer harbor one month before the survey are presented in Table 20. The table lists the village of residence, number of fish eaten per week, whether fish were eaten within 48 hours of urine collection, age, sex, and analyte levels. A 35-year-old man from Pago Pago village who reported eating fish caught in inner Pago Pago Harbor, with low intake of fish per week, had a urine arsenic level of 224 μg/g, a blood mercury level of 4.4 μg/L, a urine mercury level of 10 μg/g, and levels of all other analytes below the established reference intervals. The other participant, a 54-year-old man also from Pago Pago village, reported eating fish caught in outer Pago Pago Harbor, with an average fish intake of 3 units per week, had a urine arsenic level of 245.45 μg/g, a blood mercury level of 11.2 μg/L, and levels of all other analytes below the established reference levels. In contrast, a 46-year-old man reporting a fish intake of 21 units per week from the outer harbor, had a urine arsenic level of 41.24 μg/g and a blood mercury level of 9.80 μg/L.

DISCUSSION

This study found very few of the participants eating fish caught in the contaminated inner Pago Pago Harbor. Residence in the target area was not associated with significant increases in any of the measured analytes nor were any of the analytes measured at levels of immediate clinical significance. Arsenic and mercury levels were associated wtih increased levels of fish consumption in one age group.

Study Limitations

Certain issues were identified that limited the interpretations of the findings of this biologic indicators of exposure study. These limitations included (1) a lack of information on individual exposure to each type of fish (analyte concentration, amount, and duration); (2) inadequate environmental exposure characterization before data collection; (3) the cross-sectional design of the study, which prevented distinguishing past exposures from current exposures; and (4) reliance on self-reported information on behaviors and risk factors.

The quantity of fish eaten by type was not characterized. This reduced the ability of investigators to assess any possible association between analytes and quantitative exposures to fish type. Different species of fish migrate in and out of Pago Pago Harbor during the year (*1*). The study questionnaire did not quantify the amount of fish consumed by species; therefore, it was not possible to assess differences in exposure attributable to species. The concentrations of metals in fish also vary with the species, age, and size of the fish.

The study objective to collect urine and blood for examination of exposure levels to each analyte was met. However, had fish, seawater, and sediment sampling also been conducted during the time of this study in both the target and comparison areas, the exposure characterization for both islands would have improved the assessment of biologic measures of human exposure.

The cross-sectional study design could not determine whether levels of certain analytes (for example, cadmium) resulted from historical exposure that might have ended, or were the result of existing and continuing exposure. Furthermore, the study design did not permit a determination of a cause-effect relationship because exposure and risk factors were measured at the same time. In addition, the study relied upon self-reported behaviors and risk factors, which might not have accurately represented exposure.

Interpretation

Heavy metal contamination of fish, seawater, and sediments in inner Pago Pago Harbor, concern about possible health effects from the consumption of fish from the harbor, and reportedly high levels of fish consumption among South Pacific Islanders led to this investigation. The purpose of the study was to measure and compare levels of selected heavy metal exposures in residents living near inner Pago Pago Harbor with those of residents of a comparison area, and determine if exposure levels increased with increased fish consumption.

There are several important similarities and differences between this study and previous studies of Native American fish consumers in Wisconsin (*25*) and Minnesota (*26*). The Wisconsin study examined total blood mercury levels in 465 adult Chippewa Indians 18 years of age and older. Peterson and Kanarek (*25*) reported that during May 1990, when Wisconsin members of the tribe of Chippewa Indians ate the most fish, 50% of the respondents ate no more than one fish meal per week. Members of the Wisconsin tribe study group were questioned about their consumption of 10 common species of fish (of both commercial and locally caught varieties) in the preceding 2 months. The study revealed that 64 (20%) of the participants had mean mercury concentrations ≥5 μg/L, and that a statistically significant association existed ($p = .001$) with recent walleye fish consumption.

In the Minnesota study, hair analysis was used to examine total blood mercury, methylmercury, and mercury levels in 238 Chippewa Indians 6 years of age or older. ATSDR reported that approximately 95% of the Minnesota Chippewa Indians ate no more than one fish meal per week from May through August 1991 (*26*). The findings in the Minnesota study were that consumption of bass and a higher number of fish meals per week were associated with higher blood mercury levels. A statistically significant association was not found between walleye consumption and blood mercury levels ≥10 μg/L, although statistically significant associations were found between walleye and trout consumption.

The American Samoa study examined the levels of urine arsenic, cadmium, chromium, mercury, and nickel, and blood mercury and lead in 207 Samoans. Approximately 70% of American Samoan Natives reported that they ate no more than one fish meal per week in June and July 1991. The level of fish consumption in the study populations was less than expected by the investigators in all three studies. Few participants reported eating fish from Pago Pago Harbor.

Low levels of fish consumption in American Samoa can be attributed to a few reasons. First, the health advisory, which warned residents not to eat fish from the inner harbor and always to gut and clean fish from the outer harbor, was in effect for at least 7 months before the beginning of the study. In American Samoa, approximately 77% of the target group and 55% of the comparison group reported that they knew about the health advisory. A high proportion of participants in the target and comparison groups (82% and 61%, respectively) in American Samoa also reported they were concerned about contamination in Pago Pago Harbor. Another reason fish consumption may have been lower was because Hurricane Val devastated much of Pago Pago Harbor in November 1991. This occurred one month after the health advisory and reportedly limited the regular supply of fish sold at markets around the harbor.

The findings in American Samoa of statistically significant exposure levels of urine arsenic and blood mercury among 26- through 45-year-olds was not found in the other two age groups; however, this finding might have been related to the higher amounts of fish eaten by this age group. High fish consumers in this age group were more than six times as likely to have an elevated blood mercury level (OR = 6.23; CI = 1.62 - 26.38) than low fish consumers.

The levels of mercury or arsenic reported in this study probably were not at levels normally associated with adverse health effects. There have been several epidemiologic studies of exposure to heavy metals in fish-consuming populations (*25-29*). Minimata disease, a severe neurologic disorder discovered in Japan, is associated with blood mercury levels of ≥400 μg/L in adults (*30*), although milder symptoms are believed to occur at lower levels. A study of Cree Indians in northwestern Quebec, Canada, found marginal evidence for mild neurologic effects for mercury levels in hair of 20 μg/g (equivalent to a maximum blood mercury level of 80 μg/L) (*31*). However, other studies of Peruvian Indians with a mean blood mercury level of 82 μg/L (ranging as high as 275 μg/L) (*28*) and coastal Italians with mean blood levels of 60 to 70 μg/L (*32*) did not find health effects. A study of 45 cannery workers (mean blood mercury level of 64 nanograms per mililiter (ng/mL), and 88 Korean fishermen (mean blood mercury level of 30 ng/mL) consuming large quantities of fish in American Samoa found no clinical evidence of hypertension (a common finding in Minimata disease) or mercury poisoning, although blood methylmercury levels reached 265 ng/mL, and hair organic mercury levels were as high as 47.8 μg/g (*27*).

Adverse outcomes might not have been present at the low levels of biologic exposure in American Samoa. It seems unlikely that American Samoan Natives were suffering any adverse health effects from their urine arsenic levels; indeed, the reported levels might have been related to fish consumption within 48 hours of testing. The biologic half-life of ingested fish arsenic in humans is estimated to be less than 20 hours, with total clearance in approximately 48 hours (*4*). It also seems unlikely that they were suffering any adverse health effects from blood mercury exposure. The study used total blood mercury levels as a surrogate for blood methylmercury because methylmercury has been found to be the major component of blood mercury in nonoccupationally exposed individuals. However, blood mercury levels reflect recent exposure (within the previous 30 to 90 days), and urine tests measure chronic exposure, which might be the most relevant measure for assessing the potential for health effects (*17*). It is also unlikely that American Samoans were suffering any adverse health effects from chronic mercury exposure. In the American Samoa target group there were no urine mercury levels ≥20 μg/L, and only one sample with a level of 26.4 μg/L was reported in the comparison group.

None of the other metal levels were of immediate clinical significance. All study participants had urine cadmium levels below established reference levels, and only one child (a 9-year-old from the comparison area) had a blood lead level higher than the reference level of 10 μg/dL.

CONCLUSIONS

1. Approximately 98% of the target population complied with the health advisory by not eating fish caught in inner Pago Pago Harbor. Only two participants in the target group and no participants from the comparison group ate fish from inner Pago Pago Harbor.

2. Geometric mean urine arsenic levels in the comparison group (Ta'U) were statistically significantly higher than in the target group (Tutuila).

3. Urine arsenic and blood mercury levels were statistically significantly associated with high levels of fish consumption in participants 26 through 45 years of age in the target population.

4. All study participants had urine cadmium levels below the World Health Organization occupational reference level of 5 μg/g creatinine.

5. Only one child had a blood lead level higher than the Centers for Disease Control and Prevention reference level of 10 μg/dL for preventing lead poisoning in young children.

6. None of the metal levels was of immediate clinical significance.

7. On the basis of multivariate modeling, neither area of residence nor fish intake substantially predicted urine or blood analyte levels.

RECOMMENDATIONS

1. All participants with metal exposure levels greater than laboratory reference values should consult with a physician to determine if additional testing or other clinical followup is indicated.

2. Residents of American Samoa who eat fish should continue to follow the health advisory, which states that fish from inner Pago Pago Harbor should not be eaten and that fish from outer Pago Pago Harbor should always be gutted and cleaned before eating.

3. Periodic monitoring of metals in fish known to be consumed by American Samoan Natives should be conducted on fish caught in Pago Pago Harbor and surrounding waters to determine if the contamination problem is widespread and continuing.

AUTHORS AND ACKNOWLEDGEMENTS

Authors

James T. Walker, DVM, MPH, ATSDR* (Principal Investigator)
Michael A. McGeehin, PhD, MSPH
Robert F. Spengler, ScD
Robert W. Amler, MD, MS
Kelli C. Davis, MPH (Field Coordinator)
*CDC EIS Officer (Epidemic Intelligence Service)

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    Lynn Berlad
    Gwen Eng

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TABLES

Table 1.—Participation rates for target and comparison groups, American Samoa, 1992.

Category	Target (%)	Comparison (%)
Subjects selected	243 (100)	225 (100)
Unable to locate*	140 (58)	119 (53)
Refused	0 (0)	2 (1)
Interviewed	103 (42)	104 (46)

*Unable to locate were those reported by family or public health nurse "off island" or not reached after at least three attempts by telephone or visit or both to residence.

Table 2.—Comparison of participants selected and interviewed by village between the target and comparison communities, American Samoa, 1992.

Samoa Health Study		Selected		Interviewed	
		No.	%	No.	%
Target	Atu'u	66	27	31	30
	Pago Pago	68	28	40	39
	Fagatogo	109	45	32	31
	Total	243	100	103	100
Comparison	Faleasao	59	26	35	34
	Fitiuta	84	37	35	34
	Ta'u	82	36	34	32
	Total	225	100	104	100
Total		468	100	208	100

Table 3.—Demographic and other characteristics of target and comparison communities, American Samoa, 1992.

Category	Target n = 103 Number (%)	Comparison n = 104 Number (%)	Totals n = 207 Number (%)
Age group (years)			
8-25	37 (36)	35 (34)	72 (35)
26-45	31 (30)	33 (31)	64 (31)
46-75	35 (34)	36 (35)	71 (34)
Sex			
Male	48 (47)	52 (50)	100 (48)
Female	55 (53)	52 (50)	107 (52)
Education			
Less than high school	42 (41)	60 (58)	102 (49)
At least high school	60 (58)	40 (38)	100 (48)
Refuse/Don't know	1 (1)	4 (4)	5 (2)
Income			
Less than $10,000 per yr	25 (24)	62 (60)	87 (42)
More than $10,000 per yr	43 (42)	24 (23)	67 (32)
Refuse	1 (1)	1 (1)	2 (1)
Don't know	34 (33)	17 (16)	51 (25)
Fish consumption*			
High ≥2	49 (48)	52 (50)	101 (49)
Low <2	54 (52)	52 (50)	106 (51)

*Fish consumption is the product of the portion of fish eaten in an average meal and the number of fish meals eaten per week.

Table 4.—Distribution of how often participants ate fish each week in the month prior to the study for target and comparison groups, American Samoa, 1992.

Fish Meals/Week	**Area of Residence**		**Total # (%)**
	Target	**Comparison**	
#	**# (%)**	**# (%)**	
0	18 (18)	14 (14)	32 (16)
<1	14 (14)	17 (17)	31 (15)
1	33 (33)	38 (37)	71 (35)
>1	36 (35)	34 (32)	70 (34)
Total	101 (100)	103 (100)	204 (100)

Excludes one comparison and two target participants because of lack of information.

Table 5.—Comparison of low versus high levels of fish consumption by village between the target and comparison communities, American Samoa, 1992.

Age Group (Years)		Low Fish Consumption n = 106		High Fish Consumption n = 101	
		No.	%	No.	%
Target	8 - 25	30	83	6	17
	26 - 45	11	41	16	59
	46 - 75	13	33	27	67
	Total	54	52	49	48
Comparison	8 - 25	26	76	8	24
	26 - 45	16	47	18	53
	46 - 75	10	28	26	50
	Total	52	50	52	50

Fish consumption is the product of the exposure variable "Fish Intake" (the portion of fish eaten in an average meal) times the number of fish meals eaten per week; low <2, high ≥2.

Table 6A.—Urine analyte results, target and comparison groups, American Samoa, 1992.

Urine Analyte ($\mu g/g$* of creatinine)	Target (n = 97)		Comparison (n = 87)		t-test
	Range†	Geometric Mean	Range†	Geometric Mean	
Arsenic	2.30 - 356.10	47.47	12.50 - 2,426.90	94.63	p = 0.001
Cadmium	0.10 - 3.50	0.29	0.10 - 3.80	0.37	p = 0.114
Chromium	0.10 - 3.20	0.27	0.10 - 2.40	0.30	p = 0.606
Mercury	0.50 - 17.80	2.89	0.50 - 26.40	2.83	p = 0.794
Nickel	0.10 - 16.40	1.32	0.10 - 20.80	1.22	p = 0.588

*Micrograms per gram.

†Lower value of range is detection limit of laboratory test (except arsenic).

Table 6B.—Blood analyte results, target and comparison groups, American Samoa, 1992.

Blood Analyte	**Target (n = 97)**		**Comparison (n = 88)**		**t-test**
	Range*	**Geometric Mean**	**Range***	**Geometric Mean**	
Lead (µg/dL†)	0.80 - 11.90	3.94	0.60 - 12.60	3.94	p = 0.950
Mercury (µg/L§)	0.80 - 43.80	6.75	0.70 - 59.40	6.62	p = 0.888

*Lower value of range is detection limit of laboratory test (except arsenic).
†Micrograms per deciliter.
§Micrograms per liter.

Table 7.—Statistically significant urine analytes, three age groups, target and comparison groups, American Samoa, 1992.

Analyte	Age Group	Target			Comparison			n¶	t-test
		n*	Mean†	SD§	n	Mean	SD		
Arsenic	8 - 25	35	25.28	0.89	33	83.10	1.00	68	p=0.010
	26 - 45	28	55.15	1.06	27	75.94	0.77	55	p=0.204
	46 - 75	34	79.84	0.80	27	137.0	0.69	61	p=0.001
Mercury	8 - 25	35	2.23	0.67	33	2.64	0.69	68	p=0.306
	26 - 45	28	3.35	0.54	27	2.41	0.51	55	p=0.023
	46 - 75	34	3.39	0.58	27	3.63	0.60	61	p=0.653

* Group total.
† Geometric mean.
§ Standard Deviation.
¶ Study total.

Table 8A.—Urine and blood analyte results by level of fish consumption, for participants 8 through 25 years of age, American Samoa, 1992.

Age Group (8 through 25 years of age)	**Level of Fish Consumption***		
	High (n = 12)	**Low (n = 56)**	
Urine Analyte (μg/g† creatinine)	**Geometric Mean**	**Geometric Mean**	**t-test**
Arsenic	42.10	45.15	p = 0.795
Cadmium	0.14	0.15	p = 0.673
Chromium	0.25	0.27	p = 0.732
Mercury	2.56	2.39	p = 0.756
Nickel	1.21	1.60	p = 0.663
Blood Analyte			
Mercury (μg/L§)	4.14	3.60	p = 0.527
Lead (μg/dL¶)	2.80	3.63	p = 0.142

*Fish consumption is the portion of fish eaten per meal times the number of fish meals eaten per week; high is ≥ 2; low is <2.

†Micrograms per gram.

§Micrograms per liter.

¶Micrograms per deciliter.

Table 8B.—Urine and blood analyte results by level of fish consumption, for participants 26 through 45 years of age, American Samoa, 1992.

Age Group (26 through 45 years of age)	**Level of Fish Consumption***		**t-test**
	High (n = 29)	**Low (n = 26)**	
Urine Analyte (μg/g† creatinine)	**Geometric Mean**	**Geometric Mean**	
Arsenic	80.64	50.40	p = 0.057
Cadmium	0.31	0.44	p = 0.146
Chromium	0.27	0.24	p = 0.591
Mercury	2.72	3.00	p = 0.535
Nickel	1.06	1.20	p = 0.677
Blood Analyte			
Mercury (μg/L§)	10.10	6.89	p = 0.007
Lead (μg/dL¶)	4.44	3.67	p = 0.225

*Fish consumption is the portion of fish eaten per meal times the number of fish meals eaten per week; high is ≥ 2; low is <2.

†Micrograms per gram.

§Micrograms per liter.

¶Micrograms per deciliter.

Table 8C.—Urine and blood analyte results by level of fish consumption, for participants 46 through 75 years of age, American Samoa, 1992.

Age Group (46 through 75 years of age)	Level of Fish Consumption*		t-test
	High (n = 44)	Low (n = 17)	
Urine Analyte (μg/g† creatinine)	**Geometric Mean**	**Geometric Mean**	
Arsenic	106.70	90.02	p = 0.213
Cadmium	0.73	0.67	p = 0.817
Chromium	0.35	0.29	p = 0.655
Mercury	3.39	3.71	p = 0.597
Nickel	1.25	0.98	p = 0.526
Blood Analyte			
Mercury (μg/L§)	9.97	12.18	p = 0.654
Lead (μg/dL¶)	4.18	5.16	p = 0.139

*Fish consumption is the portion of fish eaten per meal times the number of fish meals eaten per week; high is ≥2; low is < 2.

†Micrograms per gram.

§Micrograms per liter.

¶Micrograms per deciliter.

Table 9.—Urine arsenic results among participants who ate fish versus those who did not eat fish within 48 hours of urine collection, target and comparison groups, American Samoa, 1992.

Ate fish within 48 hours of urine collection	Target (n = 80)			Comparison (n = 82)		
	Range	**Geometric Mean**	**t-test**	**Range**	**Geometric Mean**	**t-test**
Yes	30.6 - 288.6	119.58	p = <.001	19.1 - 2,426.9	109.73	p = 0.194
No	2.3 - 356.1	40.53		12.5 - 611.8	85.46	

Table 10.—Comparison of geometric mean urine arsenic levels for statistically significant variables, three age groups, American Samoa, 1992.

Urine Arsenic				
Characteristic	Yes	No	Total	t-test
	Mean	Mean		
8- to 25-year-olds				
House built at least by 1976	56.83	29.08	53	p = 0.014
Less than high school graduate	56.27	29.96	66	p = 0.030
26- to 45-year-olds				
Ate at least two fish meals per week	80.64	50.40	55	p = 0.057
Your hobbies past 90 days	88.23	51.46	51	p = 0.049
Family hobbies past 90 days	90.92	48.42	52	p = 0.015
Family jobs past 90 days	102.51	53.52	51	p = 0.022
Household income less than $10,000 per year	81.45	49.40	45	p = 0.050
Less than high school graduate	113.30	57.97	55	p = 0.046
46- to 75-year-olds				
Caught fish previous month	235.10	86.49	59	p = 0.049

Table 11.—Odds ratios and 95% confidence intervals with elevated urine arsenic levels, American Samoa, 1992.

Variable	8- to 25-year-olds		26- to 45-year-olds		46- to 75-year olds	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Area of residence	0.17	0.05-0.53	0.61	0.19-1.93	0.96	0.32-2.83
Smoked	0.49	0.11-2.06	0.80	0.24-2.63	0.28	0.09-0.88
Drank more than one drink per week	3.44	0.31-175.0	4.05	0.60-34.02	0.86	0.01-17.34
Fish consumption	0.92	0.24-3.48	1.07	0.34-3.37	1.64	0.50-5.40
Knew about health advisory	0.52	0.18-1.49	0.52	0.15-1.76	1.20	0.32-4.49
Changed fishing habits from harbor	0.43	0.14-1.31	0.73	0.22-2.45	0.90	0.30-2.71
Concerned about fish contamination in harbor	4.55	1.38-15.54	1.83	0.49-7.01	3.11	0.73-15.44
Household income less than $10,000 per yr.	2.0	0.49-8.32	3.11	0.45-14.20	0.26	0.06-1.00
Less than high school graduate	-	-	2.19	0.44-12.07	0.15	0.15-1.67
Used public water for drinking	0.44	0.06-2.50	1.86	0.41-8.75	1.02	0.14-5.80
Used public water for cooking	0.58	0.10-3.00	2.40	0.49-12.89	0.40	0.01-4.40

Table 12.—Comparison of geometric mean urine cadmium levels for statistically significant variables, American Samoa, 1992.

Urine Cadmium				
Characteristic	Yes	No	Total	t-test
	Mean	Mean		
8- to 25-year-olds				
Drank alcohol at least once per week	0.14	0.34	68	p = 0.034
46- to 75-year-olds				
House built before 1976	0.56	0.96	57	p = 0.009
How often ate fish*	0.75	0.32	61	p = 0.031
Household income less than $10,000	1.01	0.53	47	p = 0.010
Less than high school graduate	0.86	0.50	60	p = 0.014

* yes = less than once a week; no = did not eat fish

Table 13.—Comparison of geometric mean urine mercury levels for statistically significant variables, American Samoa, 1992.

Urine Mercury				
Characteristic	**Yes**	**No**	**Total**	**t-test**
	Mean	**Mean**		
8- to 25-year-olds				
Smoked more than 100 cigarettes	1.00	1.68	68	p = 0.063
1-Packyears (0 vs. 1-20 pk/yr)	0.86	1.70	68	p = 0.023
Less than high school graduate	1.93	1.09	66	p = 0.002
26- to 45-year-olds				
Caught fish previous month	0.74	1.26	53	p = 0.098

Table 14.—Comparison of geometric mean urine nickel levels for statistically significant variables, American Samoa, 1992.

Urine Nickel				
Characteristic	Yes Mean	No Mean	Total	t-test
8- to 25-year-olds				
Smoked more than 100 Cigarettes	1.00	1.68	68	p = 0.063
1-Packyears (0 vs 1-20 pk/yr)	0.86	1.70	68	p = 0.023
Less than high school graduate	1.93	1.09	66	p = 0.002
26- to 45-year-olds				
Caught fish last month	0.74	1.26	53	p = 0.098

Table 15.—Comparison of geometric mean blood mercury levels for statistically significant variables, three age groups, American Samoa, 1992.

Blood Mercury				
Characteristic	Yes	No	Total	t-test
	Mean	Mean		
8- to 25-year-olds				
1-Packyears (0 vs 1-20 pk/yr)	5.75	3.39	68	p = 0.014
2-Packyears (0 vs 21-40 pk/yr)	8.94	3.39	67	p = 0.002
Caught fish last month	5.00	3.49	64	p = 0.063
You worked in fish cannery	8.94	3.39	67	p = 0.002
Family hobbies past 90 days	3.03	4.31	67	p = 0.031
Your hobbies past 90 days	8.00	3.56	68	p = 0.035
Less than high school graduate	3.10	5.10	66	p = 0.002
26- to 45-year-olds				
Smoked more than 100 cigarettes	10.60	7.39	56	p = 0.015
How often ate fish*	9.12	6.05	55	p = 0.033
Ate less than 2 fish meals per week	10.07	6.89	56	p = 0.001
Your job past 90 days	13.20	7.46	56	p = 0.001
46- to 75-year-olds				
Caught fish last month	17.64	9.58	59	p = 0.018
Household income less than $10,000 per year	7.46	14.01	47	p = <.01
Less than high school graduate	8.76	14.44	60	p = 0.007

* yes = less than once a week or more; no = did not eat fish

Table 16.—Odds ratios and 95% confidence intervals with elevated blood mercury levels, three age groups, American Samoa, 1992.

Variable	8- to 25-year-olds		26- to 45-year-olds		46- to 75-year-olds	
	OR*	95% CI†	OR*	95% CI†	OR*	95% CI†
Area of residence	2.25	0.70-7.40	0.74	0.22-2.51	1.94	0.10-117.94
Ever smoked	1.70	0.51-5.74	12.43	2.85-59.26	9.82	0.45-589.48
Drank more than one drink per week	-	-	0.14	0.00-1.57	-	-
Fish consumption	1.01	0.28-3.67	6.23	1.62-26.38	-	-
Knew about health advisory	8.64	1.83-53.48	1.02	0.28-3.81	0.48	0.01-9.84
Changed fishing habits from harbor	1.15	0.36-3.68	1.59	0.44-5.79	-	-
Concerned about fish contamination in harbor	1.88	0.43-8.20	1.20	0.31-4.68	-	-
Household income less than $10,000 per year	0.12	0.02-0.53	1.16	0.29-4.69	-	-
Less than high school graduate	0.10	0.02-0.47	1.29	0.22-6.87	0.22	0-4.49
Used public water for drinking	0.67	0.06-5.21	0.78	0.15-4.47	-	-
Used public water for cooking	0.93	0.07-8.80	0.60	0.10-3.69	-	-

* Odds ratio.
† Confidence interval.

Table 17A.—Linear regression model for urine arsenic (natural log values of corrected urine) in 8- to 75-year-olds, American Samoa, 1992.

Variable*	Parameter	Standard Error	p-Value
Intercept	3.740	0.183	<.001
Area of residence	-0.531	0.142	<.001
Fish intake	0.056	0.016	<.001
Age	0.014	0.004	<.001
Jobs last 90 days	0.368	0.146	0.013
You catch fish	0.303	0.164	0.066
High school graduate	-0.246	0.134	<.067

Model F-ratio = 12.07, p = 0.0001; adj r^2 = 0.28; n = 178.
*All variables coded as 1 (yes) or 0 (no) except fish intake and age as continuous variables.

Table 17B.—Logistic regression model for urine arsenic* (natural log of corrected urine values) among 8- to 75-year-olds, American Samoa, 1992.

Variable	Beta	Standard Error	OR†	95% CI§
Intercept	0.08	0.29		
Area of residence	0.55	0.31	0.58	0.43-1.06
Fish consumption	0.43	0.29	1.54	0.87-2.72
You catch fish	0.73	0.38	2.08	1.00-4.36

n = 202
*Urine arsenic results dichotomized into <80 μg/g and ≥ 80 μg/g creatinine.
† Odds ratio.
§ Confidence interval.

Table 18A.—Linear regression model for blood mercury (natural log values) in 8- to 75-year-olds, American Samoa, 1992.

Variable*	Parameter	Standard Error	p-Value
Intercept	0.937	0.125	<.001
Area of residence	-0.050	0.097	<.607
Fish intake	0.025	0.011	<.028
Age	0.016	0.003	<.001
Packyear (smoking)	0.012	0.005	0.015
You catch fish	0.257	0.113	0.024
High school graduate	0.415	0.092	<.001

Model F-ratio = 20.14, p = 0.0001; adj r^2 = 0.42; n = 182.
*All variables coded as 1 (yes) or 0 (no) except fish intake, age, and packyear as continuous variables.

Table 18B.—Logistic regression model for blood mercury* (natural log values) among 8- to 75-year-olds, American Samoa, 1992.

Variable	Beta	Standard Error	OR†	95% CI§
Intercept	4.88	0.77		
Area of residence	0.61	0.40	1.84	0.84-4.02
Fish consumption	0.52	0.38	1.68	0.79-3.57
Age	0.05	0.01		
Packyear (smoking)	0.03	0.02	1.38	0.76-1.87
You catch fish	1.22	0.46	3.37	1.36-8.36
High school graduate	1.17	0.40	3.22	1.46-7.09

n = 205
*Blood mercury results dichotomized into <10 μg/L and ≥10 μg/L.
† Odds ratio.
§ Confidence interval.

Table 19.—Linear regression model for urine cadmium (natural log values of corrected urine) in 8- to 75-year-olds, American Samoa, 1992.

Variable*	Parameter	Standard Error	p-Value
Intercept	3.740	0.183	<.001
Area of residence	-0.396	0.134	<.004
Fish intake	-0.019	0.016	<.263
Age	0.034	0.004	<.001
Packyear smoking	0.167	0.007	<.020

Model F-ratio = 26.05, p = 0.0001; adj r^2 = -.37; n = 180.
*All variables coded as 1 (yes) or 0 (no) except fish intake and age as continuous variables.

Table 20.—Blood and urine analyte levels, inner versus outer harbor participants who ate fish caught in Pago Pago Harbor one month before the survey, American Samoa, 1992.

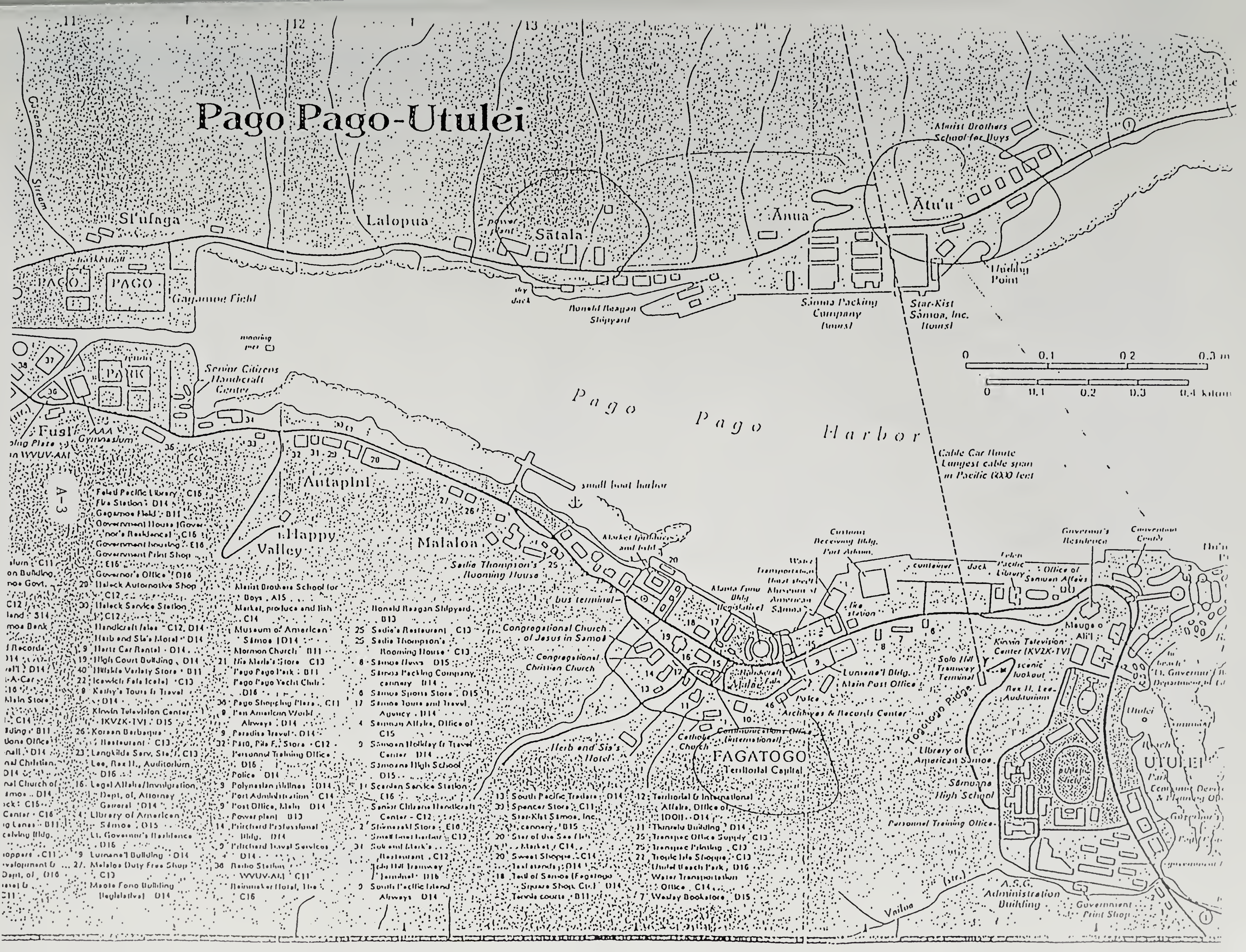
Variable	**Inner Harbor**		**Outer Harbor**			
Village of residence	**Pago Pago**	**Pago Pago**	**Fagatogo**	**Fagatogo**	**Pago Pago**	**Pago Pago**
Fish intake per week	1	1	21	1	4	3
Ate fish last 48 hours	No	No	Unknown	No	Yes	Yes
Age (years)	10	35	46	26	40	54
Sex	M	M	M	M	M	M
Urine arsenic	43.04	224.32	41.24	12.20	30.63	245.45
Urine cadmium	0.13	3.46	0.10	0.08	0.22	0.15
Urine chromium	0.51	1.08	0.14	0.33	0.12	0.61
Urine mercury	5.82	10.00	3.02	5.12	2.91	2.73
Urine nickel	2.15	5.95	1.17	0.41	0.15	0.76
Blood lead	4.70	3.40	6.70	4.70	2.70	2.70
Blood mercury	2.40	4.40	9.80	6.90	19.30	11.20

APPENDICES

The contents of Appendices A through J are presented in their entirety as submitted by the author and have not been revised or edited to conform with Agency for Toxic Substances and Disease Registry editorial guidelines.

Appendix A—Maps of American Samoa

Pago Pago-Utulei

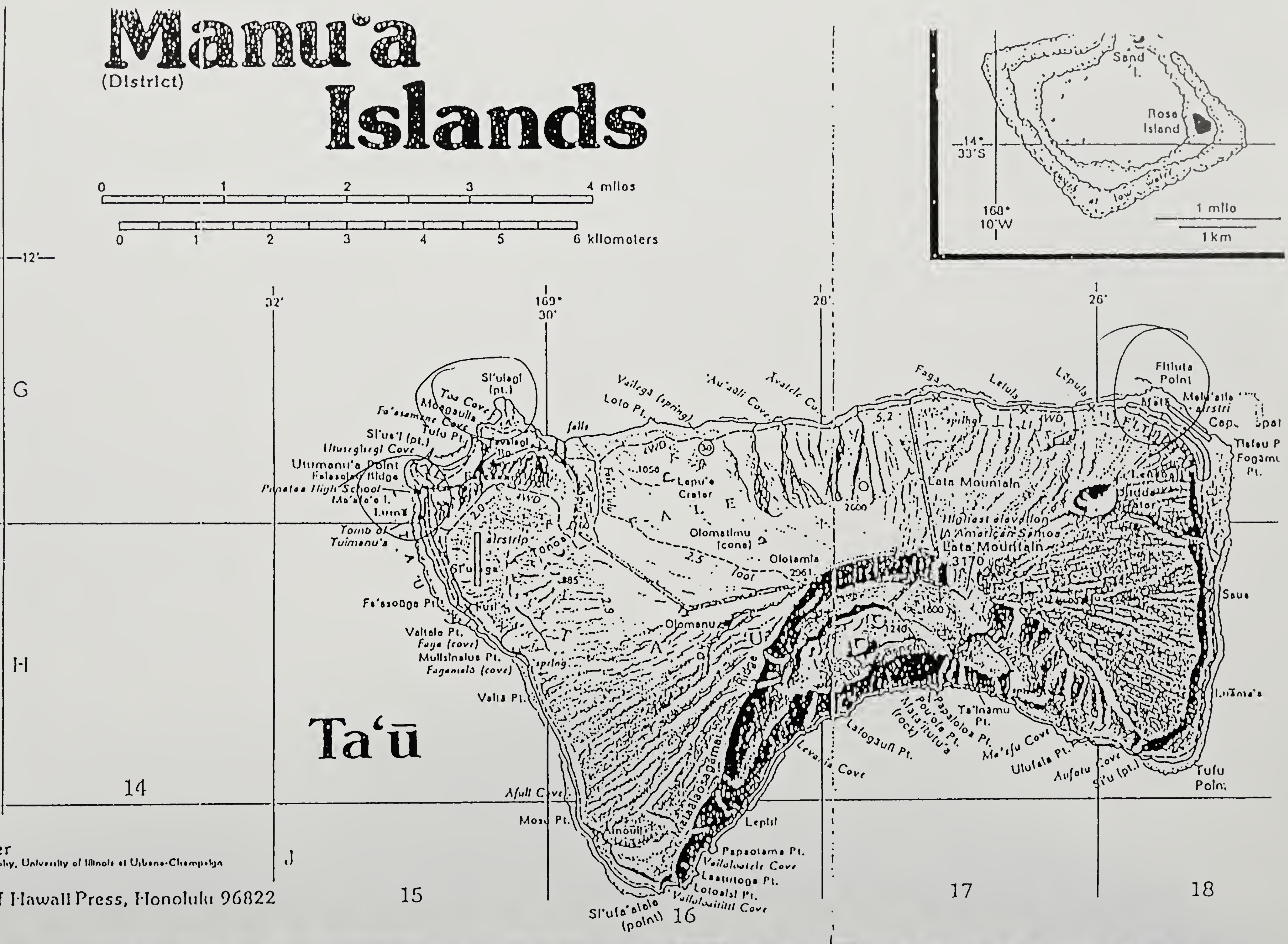


sega

A-4

lafolo Stream	F11
lulolo Point	H17
lumanu'a Point	G15
lusegisegi Cove	G15
a'aui Stream	F12
ailoga (spring)	G16
aVaiolowiliili Cove	J16
aVailoloatele Cove	J16
ala'ili Point	F12
alia Point	H15
aitolo Point	H15
a'oto Marsh	F10

Manu'a
(District)
Islands



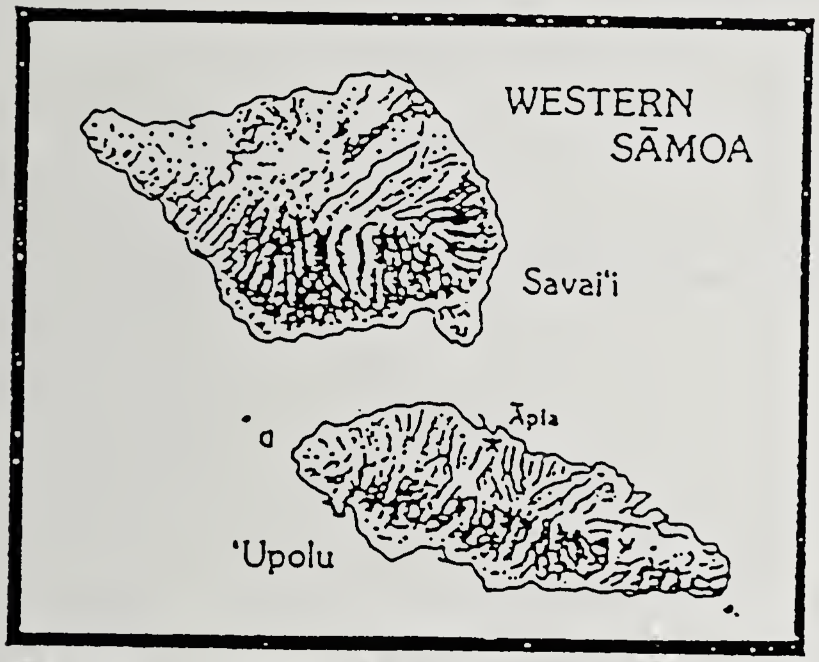
Cartography by
James A. Bier
Department of Geography, University of Illinois at Urbana-Champaign
Published by
University of Hawaii Press, Honolulu 96822

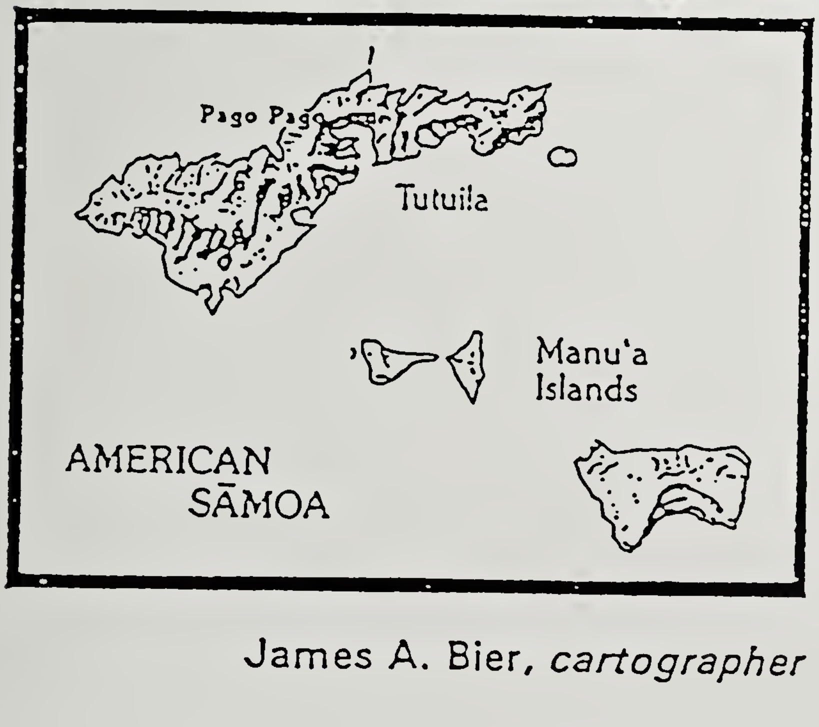
Second Edition

ISLANDS OF SĀMOA

Tutuila Manu'a 'Upolu Savai'i

Comprehensive reference and
travel maps of both American
and Western Sāmoa for resident
and visitor. An accurate guide
to the Heart of Polynesia.





James A. Bier, *cartographer*

Published by
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Honolulu, Hawaii 96822

Appendix B—Pago Pago Harbor Health Advisory

October 11, 1991

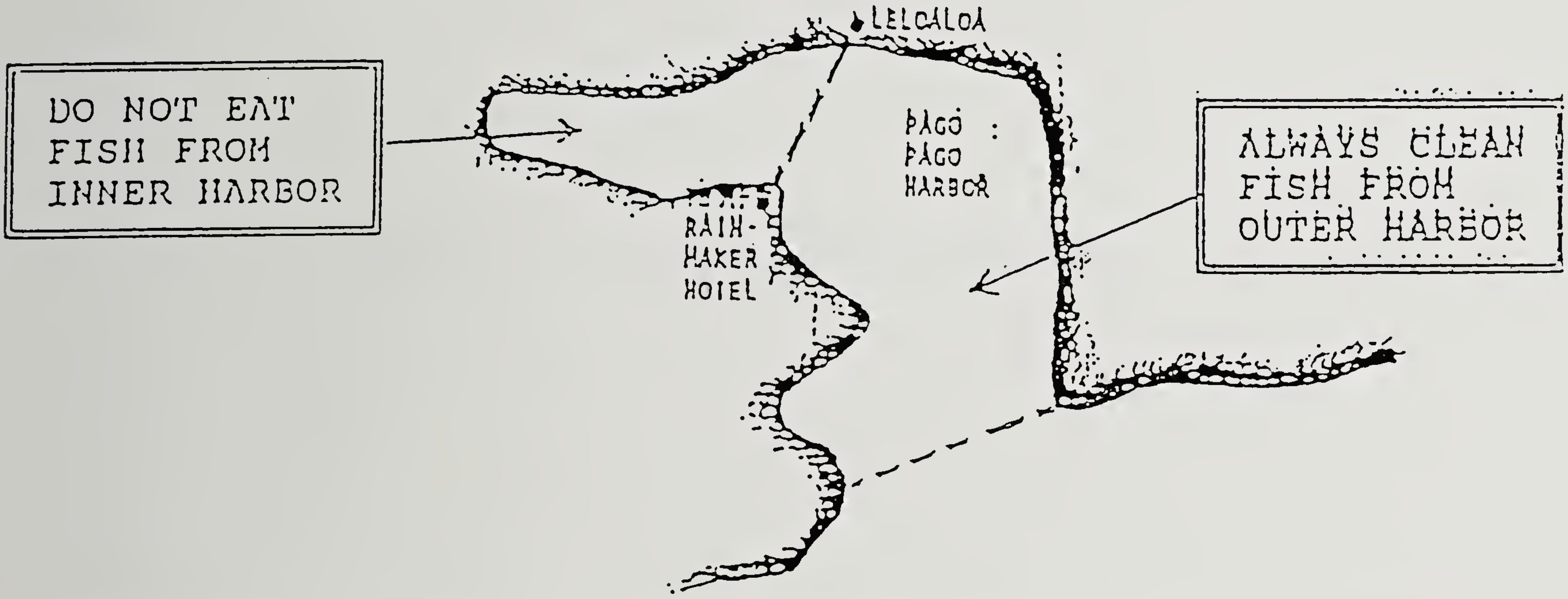
AMERICAN SAMOA GOVERNMENT
PAGO PAGO, AMERICAN SAMOA 96799

In reply refer to:

*** IMPORTANT HEALTH ADVISORY FOR PAGO PAGO HARBOR ***

SUBJECT: CONTAMINATED FISH IN HARBOR

Due to serious contamination problems in Pago Pago Harbor, we advise all people not to eat any fish caught in the inner harbor (see figure below). Fishing may continue in the outer harbor, but fish caught there should be gutted and cleaned before eating -- do not eat whole fish taken anywhere in the harbor. Reduce or eliminate the amount of harbor fish consumed, particularly by children (who are at the greatest health risk).


LEIĀLOA
DO NOT EAT FISH FROM INNER HARBOR
PAGO PAGO HARBOR
RAINMAKER HOTEL
ALWAYS CLEAN FISH FROM OUTER HARBOR

EXPLANATION: A study has shown that fish caught in the inner harbor are seriously contaminated with lead, other heavy metals, and other contaminants. A health risk analysis conducted by EPA indicates that the concentration of lead alone may reach levels that cause a permanent reduction in the intelligence of children who regularly consume 3-4 meals of harbor fish per week.

While these toxic chemicals are found throughout the fish's body, the fish's liver is particularly poisonous. Therefore, all fish taken anywhere in the harbor should be gutted and cleaned before eating. This includes small fish as well as large fish.

Although sampling for this study was limited to the inner harbor, it seems probable that contamination levels are lower in the outer harbor where there is more water exchange with clean offshore waters. Further studies are needed to verify this.

ISSUING AGENCIES: For more information, contact: American Samoa Environmental Protection Agency (633-2304), Public Health Division (633-4623), Coastal Management Program (633-5155), or Marine and Wildlife Resources (633-4456).

Appendix C—Request for Technical Assistance

AMERICAN SAMOA GOVERNMENT
PAGO PAGO, AMERICAN SAMOA 96799
DEPARTMENT OF HEALTH SERVICES
PUBLIC HEALTH DIVISION

In reply refer to:

November 27, 1991

Jeffrey Lybarger, M.D.
Director, Division of Health Studies
Agency for Toxic Substances and
Disease Registry
Atlanta, Georgia 30333

Dear Dr. Lybarger:

It was a pleasure to have had the opportunity of talking with you a week, or so ago, by long distance telephone. I also wish to recognize the help Dr. Almer so kindly contributed in channeling my mission to your office.

I am sending (priority mail) copy of the Toxicity Study material, by AECOS, Inc. - Summary of Findings and Recommendations of 3 governments agents; Risk Analysis; Information on fish catch; and justification for further studies.

The Department of Health, through the Division of Public Health, requests your office for directive and help - financial and technical personnel to conduct a study in American Samoa to try and determine: 1. blood lead, Ca, Cu, Hg, Ag, As, Cd, Ni, Zn, etc. 2. if the population's health is affected by the significant lead concentration discovered (or others) in the AECOS, Inc. Toxicity Study.

The study, we are requesting should be very important not only to answer questions posed by the findings of the preliminary study here but also baseline information for similar studies in the South Pacific area.

There is very little doubt that, from our experience, other island nations and territories of the United States in the Pacific, wish to conduct similar studies, especially the millions of tons metals from sunken ships during the Second World War which abounds numerous harbors in the area.

Two years after armistice in the Pacific (1947) a U.S. Navy tanker caught fire and sank into the harbor - it is still lying at the deepest furrow at the bottom. At about the same period of time, a U.S. Navy ship Repair Unit used red-lead for hull protection. These incidences may, or may not be, culprits of Pago Pago harbor contamination, but should be mentioned.

The study materials will be forwarded to your office through Priority Mail, and should arrive soon.

I sincerely hope that your office rules in favor of conducting this study to answer many questions, particularly the affect of lead and other metals to the human population in American Samoa.

I await your decision, but would be very happy to answer questions which you may have on this matter.

Sincerely,

Edgar C. Reid, M.D., M.P.H.
Deputy Director, Preventive and
Environmental Health Services

Iotamo T. Saleapaga, M.D.
Director of Health Services

cc: File

Appendix D—Food and Drug Administration Suggested Trace Metal Action Levels for Seafood (Figure 1)
World Health Organization Acceptable Daily Intake Limits of Trace Metals (Figure 2)

Figure 1 Suggested Trace Metal Action Levels for Seafood and Seafood Products [μg/g (ppm)]

Metal	FDA	ANHMRC[a]	CHPB[b]
Arsenic[c]	-	1.53	3.5
Cadmium	-	2.0	-
Copper	-	30.0	-
Lead	-	2.0	0.5
Mercury	1.0	-	0.5
Zinc	-	1,000.0	-

[a] Australian National Health and Medical Research Council.
[b] Canadian Health Protection Board.
[c] As the trioxide.

Figure 2 Acceptable Daily Intake Limits of Trace Metals as Suggested by FAO/WHO (PTDI) and NRC-NAS (ESADDI) Compared with Mean U.S. Daily Intake of Trace Metals Reported by FDA Total Diet Studies (μg/day)

Metal	FAO/WHO PTDI[a]	NRC-NAS ESADDI	FDA[b] Mean Daily Intake	Mean Daily Intake from 15-lb/yr U.S. Catch[c]
Antimony[d]			15	
Arsenic	182[e]	-	45	82 (43.6)[f]
Cadmium	57-72	-	15	2.0
Chromium	-	50-200	-	3.7
Copper	-	2,000-3,000	-	51
Lead	429	-	41	10[i]
Mercury[g]	33-43	-	3.9	2.1
Nickel				5.6
Selenium	-	50-200	152[h]	14
Zinc	15,000	-	17,700[h]	

[a] Calculated from the PTWI; 70-kg human.
[b] Total Diet Studies for 25-30-year-old males (FDA market basket program); Gunderson et al. (1988) except as otherwise noted.
[c] Calculated from data in Hall et al. (1978); for the breakdown of average levels for species, see Tables 6-10-6-18, which detail the distributions of species-average concentrations.
[d] EPA RfD = 4 x 10^{-4} mg/kg/day = 28 μg/day.
[e] Arsenic trioxide; not agreed upon but estimated.
[f] Data in parentheses are FDA seafood measurements given in Gunderson et al. (1988).
[g] Lowest value is methylmercury, highest total mercury.
[h] From the older total diet data of Gartrell et al. (1985).
[i] A study coauthor believes this result may be too high because of contamination.

Source: Reference 3

Appendix E—A Preliminary Toxicity of Fish Tissues AECOS, 1992

Concentrations of silver, arsenic, cadmium, and chromium in fish tissues from Pago Pago Harbor.

[Batch] Sample	Ag	As	Cd	Cr
	(mg/Kg wet tissue weight)			
muscle tissues				
[1] 1 Acanthuridae (4/20) *Acanthurus xanthopterus*	0.26	0.01	0.20	1.9
[1] lab duplicate sample	0.35	<0.01	0.20	1.2
[2] 2 Gerreidae (matu) *Gerres* sp. (4/20/90)	0.45	0.03	0.30	33.8
[2] 2 small Carangidae (lupo) *Urapsis* sp. (4/20/90)	0.15	<0.01	0.37	5.5
[4] 1 Lutjanidae (tamala) *Lutjanus fulvus* (4/24)	0.13	<0.01	0.33	4.6
[7] 2 Mugilidae mullet (4/30-5/6/90)	0.6	0.15	0.5	21.7
[11] Muglidae mullet (Oct 10-19,'90)	0.09	0.044	0.18	0.44
[12] Muglidae mullet (Oct 10-19,'90)	0.09	0.053	0.10	2.05
[13]. Acanthuridae (Oct 1990) *Acanthurus xanthopterus*	0.05	0.026	0.10	0.48
[13] lab duplicate sample	0.02	0.021	0.09	0.31
Mean	0.22	0.034	0.24	7.20
Std. Dev.	0.18	0.042	0.13	10.75
liver tissues				
[1] *Acanthurus* (4/20)	0.7	0.52	0.4	2.3
[5] Carangidae (4/30-5/6)	0.7	0.37	1.3	5.5
[7] Mugilidae (4/30-5/6)	0.7	0.79	0.4	19.1
[8] Gerreidae (4/30-5/6)	0.4	0.60	0.4	44.1
[9] *Acanthurus* (4/30-5/6)	0.4	0.27	0.3	11.7
[10] Mugilidae mullet (Oct 10-19,'90)	0.03	0.057	0.12	0.45
[12] Mugilidae mullet (Oct 10-19,'90)	0.12	0.122	0.10	0.60
[13] Acanthuridae (Oct 1990) *Acanthurus xanthopterus*	0.05	0.156	0.13	0.19
[13] lab duplicate sample	0.06	0.12	0.17	0.05
Mean	0.35	0.334	0.37	9.33
Std. Dev.	0.28	0.240	0.35	13.74

Conçentrations of copper, mercury, nickel, lead, and zinc in fish tissues from Pago Pago Harbor

[Batch] Sample	Cu	Hg	Ni	Pb	Zn
	(mg/Kg wet tissue weight)				
muscle tissues					
[1] 1 Acanthuridae (4/20) Acanthurus sp.	0.61	0.06	1.3	1.1	9.3
[1] lab duplicate	0.44	0.04	1.9	0.9	8.5
[2] 2 Gerreidae Gerres sp. (4/20)	1.32	<0.01	11.8	1.6	16.5
[3] 2 small Carangidae Urapsis sp. (4/20)	0.29	0.05	3.1	1.9	23.0
[4] 1 snapper or tamala Lutjanus fulvus	0.46	0.08	4.1	2.5	12.2
[7] 2 Mugilidae (4/30-5/6/90)	1.6	0.02	8.1	2.6	18.6
[11] Muglidae mullet (10/10-19)	3.38	<0.01	1.2	0.7	13.4
[12] 3 Muglidae mullet (10/10-19)	9.83	<0.01	2.9	7.9	14.6
[13] 8 acanthurids A. xanthopterus	5.62	<0.01	<0.1	0.1	3.6
[13] lab duplicate	0.5	<0.1	0.1	3.6	2.9
Mean	2.4	0.03	3.8	2.9	12.3
Std. Dev.	3.0	0.03	3.4	2.1	6.0
liver tissues					
[1] Acanthuridae (4/20) A. xanthopterus	5.8	0.46	1.9	1.6	75.6
[5] Carangid	5.5	0.06	1.2	1.4	32.9
[7] Mugilidae (mullet) (4/30-5/6/90)	19.2	0.05	4.8	2.1	53.9
[8] Gerreidae (4/30-5/6) Gerres sp.	3.0	0.12	11.6	3.6	45.7
[9] Acanthurids (4/30-5/6) A xanthopterus	11.7	0.23	2.4	0.7	195.6
[10] Mugilidae mullet (Oct 10-19)	2.45	<0.01	0.4	0.3	9.3
[12] Mugilidae mullet (Oct 10-19)	2.61	<0.01	0.9	73.8	13.2
[13] Acanthurids (Oct 1990) A. xanthopterus	7.73	0.16	0.3	0.4	67.7
[13] lab duplicate	11.45	0.14	0.3	<0.1	109.1
Mean	7.72	0.14	2.6	9.3	67.0
Std. Dev.	5.23	0.13	3.4	22.8	54.2

Appendix F—Power and Sample Size Calculations, Colorado and Utah

Power and Sample Size Calculations based on Data from Cadmium and Lead Studies conducted in 1987 in Leadville, Colorado and Park City, Utah.

Leadville, Colorado, September, 1987

	Blood Lead				Urine Cadmium			
Age Group	mean (ug/dl)	sd	n[1]	power[2]	mean (ng/g)[3]	sd	n[1]	power[2]
6-71 months	10.1	5.58	50	.99	.17	.23	100	.83
6-14 years	5.8	2.95	50	.99	.20	.17	50	.90
15-44 years	6.4	4.15	50	.99	.60	.92	150	.88
45-65 years	8.6	6.7	50	.94	.78	.97	100	.88

Park City, Utah, October, 1987

	Blood Lead				Urine Cadmium			
Age Group	mean (ug/dl)	sd	n[1]	power[2]	mean (ng/ml)	sd	n[1]	power[2]
6-71 months	4.35	1.97	50	.99	.12	.1	50	.91
6-16 years	4.8	2.59	50	.99	.18	.23	100	.87
17-65 years	5.39	3.65	50	.98	.27	.14	50	.99

Note: The means and standard deviations found in the Leadville and Park City studies for each age group were used to estimate the sample sizes required to achieve at least 80% power to detect a difference between target and comparison groups of at least 50%. Sample size calculations were made using both sets of data. Sample sizes were chosen so that the 80% power criteria was met for both sets of data.

[1] Sample size for each age group in the target and control groups.

[2] Power to detect a difference of 50%.

[3] Corrected for creatinine

Appendix G—Participant Consent for Interview, Blood and Urine Collection (Adult and Child Forms)

AMERICAN SAMOA HEAVY METAL & FISH EXPOSURE STUDY

Interviewer ID#:__ __ __ __
Household ID#:__ __ __ __
Participant ID#:__ __ __ __

ADULT CONSENT FOR INTERVIEW, BLOOD, AND URINE COLLECTION

Talofa (Hello). My name is (YOUR NAME), and we are here to ask for your participation in the Fish Exposure Study supported by the American Samoa Government and the Agency for Toxic Substances and Disease Registry (ATSDR). We are collecting information from American Samoans about your fishing habits and the amount and types of fish you eat. We are doing this study because of the EPA report that fish from the inner Pago Pago Harbor are contaminated with metals (for example; lead, mercury, chromium, cadmium, arsenic and nickel). The study will help us address health concerns and determine if a health problem exists.

This health study has three parts: 1) today I would like to ask you some questions about your diet, fishing habits, your job and hobbies, and the home that you live in. This questionnaire only takes about 20-30 minutes; 2) later in the interview we would like to schedule a time to collect about one tablespoon of blood and 3) a urine specimen at the health center. There is little risk with giving a blood sample. Temporary discomfort and a small bruise infrequently occur at the site where the needle enters the skin.

A benefit of participating in this study is that you will receive, at no charge, the urine and blood test results in about six months, along with a medical interpretation of your results. If you decide to participate you will need to stop eating fish for at least two days before your blood and urine are collected so that the results reflect long term exposure instead of recent exposure to the metals.

May I tell you more about this study? ___ Yes ___ No

Furnishing the information requested, including your Social Security number, is voluntary. You may choose to stop participating at any time, even after signing this consent form. If you choose not to participate, or to stop at any time, there will be no penalty. You will not loose any benefits to which you are other wise entitled.

The authority for collecting the information in this study, including your Social Security number, is The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund Act).

The results of the blood and urine tests will also be released to the Director of Health, Deputy Director of Public Health or to a designated person by the Director of Health. Every precaution will be taken to keep your data as confidential as is legally possible. Information will be kept in accordance with the U.S. Privacy Act of 1974. Your identity and the information collected during the interview will be accessible to interview personnel.

Reports written about this study will give only group information and will not identify you or other individuals specifically. Questionnaire pages with personal identifiers (for example your social security number) will be stored separately from the rest of the questionnaire to protect your privacy. Each blood and urine specimen will be assigned a unique identification number and your name will not be placed on the containers.

There is a possibility that those individuals showing abnormal test results may be contacted for retesting on future studies. Do you have any questions? If you have any questions, please feel free to ask them now. If you understand the description of this study and are willing to participate, please sign below.

I voluntarily agree to be included in this study.

(PRINT NAME) **(SIGNATURE)** **(DATE)**

If you have further questions, please call the study coordinators; Dr. James T. Walker, Dr. Edgar C. Reid or Ms. Kelli Davis, at the American Samoa Government Department of Health Services at **(684) 633-2243.**

After these dates you may reach Dr. Walker and Ms. Davis at **(404) 639-6201.**

AMERICAN SAMOA HEAVY METAL & FISH EXPOSURE STUDY

Interviewer ID #:__ __ __ __
Family Folder ID #: __ __ __ __
Participant ID #: __ __ __ __

MINOR (8-17 YRS) ASSENT FOR INTERVIEW, BLOOD AND URINE COLLECTION

Hello (Participant) my name is (Interviewer). We are with the American Samoa Government Department of Health Services. As your parents may have already told you, we are conducting a health study with technical assistance from the Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Department of Health & Human Services.

Your participation in this study will help us to determine if you have been exposed to harmful substances such as lead, arsenic, mercury and other heavy metals. If you agree to be in this study, we will only need three things from you: 1) answers to some questions today, and in a few days 2) a small blood sample, 3) and a urine sample.

The questions will only take about 20-30 minutes of your time and we will ask you to answer some questions about your health, diet, and other activities. In a few days you will need to come to the health center so that we can collect about 1 tablespoon of blood from your arm using a small needle. Temporary discomfort and a small bruise infrequently occurs at the site where the needle enters the skin. For the urine sample, you will be asked to urinate in a small cup. You will also need to stop eating fish for at least two days before your blood and urine are collected. You dont have to be in the study, but we hope that you will help us. If you decide to, you can always stop at any time.

Your parents/guardian will be mailed the results of your test in about six months with a medical interpretation of the results. Do you have any questions? Please feel free to ask any questions now. Do you understand what I read to you and will you agree to participate in this important health study? If so, please sign your name below.

Yes, I voluntarily agree to be included in this study.

CHILDS NAME (PRINT) **(SIGNATURE)**

Parent/Guardian name (PRINT) **Parent/Guardian signature**

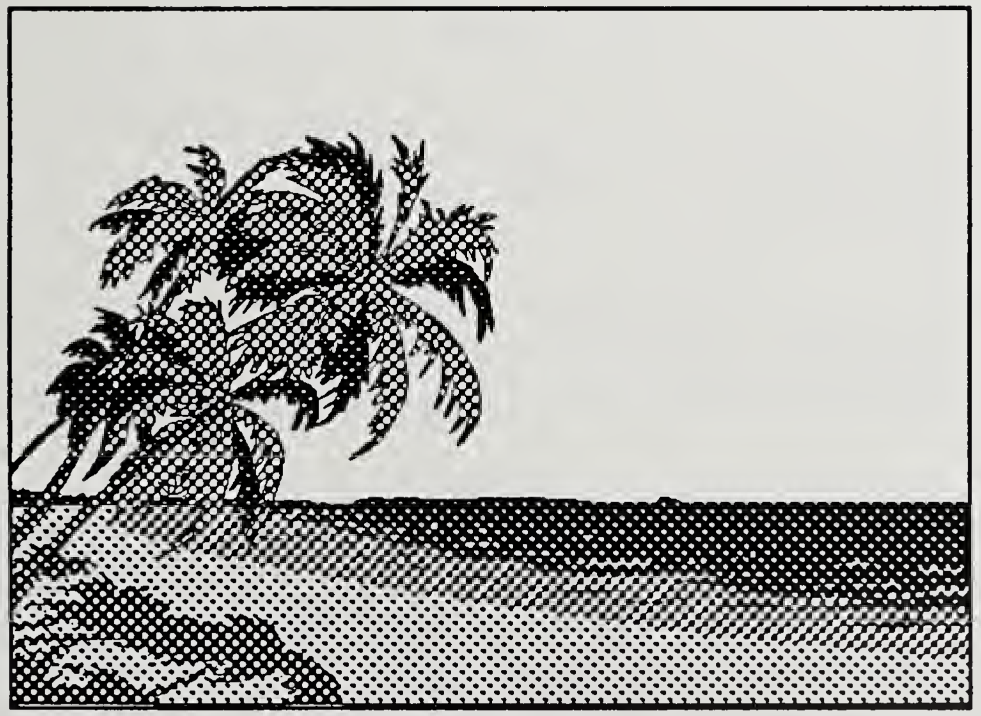
If you have questions, please call the study coordinators: Dr. Walker, Dr. Reid or Ms. Davis at the American Samoa Government Department of Health Services at (684) 633-2243.

Appendix H—American Samoa Survey Questionnaire

AMERICAN SAMOA QUESTIONNAIRE

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service

Agency for Toxic Substances and Disease Registry
Division of Health Studies
Health Investigations Branch
Atlanta, Georgia 30333



Pago Pago

Interviewer ID# __ __ __ __
Household ID#:__ __ __ __
Participant ID#:__ __ __ __

RECORD OF VISITS TO HOUSEHOLD

Visit 1: __ __/__ __/__ __ __ __:__ __ AM__ PM__
month day year time

Result: ___
Quest. completed ___ No answer ___ Home vacant ___ Refusal
___ Resident home, requests that we return on: __ __/__ __/__ __
month day year

Day of week:______________ time: __ __:__ __ AM__ PM__

Visit 2: __ __/__ __/__ __ __ __:__ __ AM__ PM__
month day year time

Result:
___ Quest. completed ___ No answer ___ Home vacant ___ Refusal
___ Resident home, requests that we return on: __ __/__ __/__ __
month day year

Day of week:______________ time: __ __:__ __ AM__ PM__

Visit 3: __ __/__ __/__ __ __ __:__ __ AM__ PM__
month day year time

Result:
___ Quest. completed ___ No answer ___ Home vacant ___ Refusal
___ Resident home, requests that we return on: __ __/__ __/__ __
month day year

Day of week:______________ time: __ __:__ __ AM__ PM__

Comments (print)____
____
____
____

(013-017)**Time** interview began: _ _:_ _   (018-023)**Date:** __/__/__

INSTRUCTIONS: IF 8-12 YRS OLD; PARENT/GUARDIAN ANSWERS
IF 13-17 YRS OLD; CHILD ANSWERS (with parent present)
IF 18 OR OLDER; PARTICIPANT ANSWERS

SECTION I DEMOGRAPHICS/PERSONAL

To begin, I would like to ask you a few questions about yourself. You can refuse to answer any question, but please answer all questions you choose to answer as truthfully as possible, as if speaking to a village minister, and as best as you can remember.

1.1 What is your/(SUBJECT's) full name?

(024-054) First ______________________________

(055-085) Middle ______________________________

(086-116) Last ______________________________

1.2 Relationship of adult to subject:
(117) 1 = self **(GO TO 1.3)**
2 = spouse
3 = parent
4 = child
5 = other relative
6 = legal guardian
(118-138) 7 = other, specify ________________
8 = refused
9 = don't know

1.2.1 Name and mailing address

(139-179) (print) ______________________________________
____

1.3 What is your/(SUBJECT's) current address?

(180-186) Number ________ (187-197) Street ________________ (198-201)Apt. ________

(202-222) Village ______________________________ (223-243)Island ________

(244-248) Zip code ______________

1.4 What are the telephone numbers that you can be reached at?

(249-258) 1.4.1.1 (__ __ __) - __ __ __ - __ __ __ __ (H)

(259-268) 1.4.1.2 (__ __ __) - __ __ __ - __ __ __ __ (W)

(269) 1.4.2.1 1= has phone
2 = no phone **(GO TO 1.4.4.1)**
8 = refused **(GO TO 1.4.4.1)**
9 = don't know **(GO TO 1.4.4.1)**

1.4.3.1 In the event that we need to contact you by telephone, when is a good time to call?

(270)

4 = in the morning
5 = in the afternoon
6 = in the evening
7 = on the weekend
8 = refused
9 = don't know

(271) 1.4.4.1 Do you/(NAME) have a social security number?

1 = yes
2 = no **(GO TO 1.5)**
8 = refused **(GO TO 1.5)**
9 = don't know **(GO TO 1.5)**

1.4.4.2 What is your (NAME's) Social Security number?

(272-280) __ __ __ - __ __ - __ __ __ __

Next, I would like to ask you some general questions about yourself and places you have lived.

1.5 What is your/(NAME's) date of birth?

(281-288) __ __/__ __/__ __ __ __ (mm/dd/year)

(289)

1 = provided birthdate
8 = refused to answer
9 = don't know

1.6 Interviewer: INQUIRE/DETERMINE GENDER OF SUBJECT

(290)

1 = Male
2 = Female

1.7 Which of the following best describes your/(NAME's) racial background? (READ THE LIST)

(291)

1 = Black
2 = White
3 = Asian or
4 = American Samoan
5 = Western Samoan
6 = Other Pacific Islander
7 = Aleut, Eskimo or Native American
8 = Refused
9 = Don't know

SECTION II RESIDENCE

Now, I would like to ask you some questions about the home you/SUBJECT live in. (Where you/subject have lived most of the time in the past 6 months). **Circle applicable answer:**

2.1 What year was the house that you live in built? (OLDEST PART)

(292)
1 = 1900-1925
2 = 1926-1950
3 = 1951-1975
4 = 1976-1990
5 = 1991-present
9 = DON'T KNOW

2.2 How long have you lived in this house?

(293-294) __ __ (years)

(295)
1 = provided answer
8 = refused to answer
9 = don't know

2.3 What type of water pipes does the home contain?

		Yes	No	DK
(296)	lead	1	2	9
(297)	plastic	1	2	9
(298)	galvanized steel	1	2	9
(299)	copper	1	2	9
(300)	iron	1	2	9
(301)	Other (specify)	1	2	9
(302-324)	______________________			

2.4 What type of water does your/SUBJECT'S household normally use MOST for: **(read A followed by choices then read B and choices)**

	Choices	**(A)** Drinking	**(B)** Cooking
(325)	Private well water	1	1
	Government of AS water	2	2
(347)	Bottled	3	3
	village	4	4
	Cistern	5	5
(326-346) (348-368)	Other ___________________	6	6
	DON'T KNOW	9	9

2.5 Has any part of your house been repainted, sanded, or refinished within the last year?

(369)
1 = Yes
2 = No
9 = DON'T KNOW

IF YES, Approximately when was this work most recently done?

(370-373) ___ ___ / ___ ___
(MONTH / YEAR) (ENTER 99 IF DON'T KNOW MONTH)

2.6 How many people are permanent residents of this household?

(374-375) __ __ number of permanent residents
88 = refused to answer
99 = don't know

SECTION III TOBACCO/ALCOHOL

The next few questions concern smoking and alcohol consumption.

3.1 Have you smoked at least 100 **cigarettes** during your entire life? (1 PACK = 20 CIGARETTES)

(376)
1 = yes
2 = no **(GO TO 3.7)**
8 = refused to answer
9 = don't know

3.2 Do you smoke cigarettes now?

(377)
1 = yes
2 = no **(GO TO 3.4)**
8 = refused to answer
9 = don't know

3.3 On the average, how many cigarettes a day do you now smoke?

(378-380) ___ ___ ___ **(GO TO 3.5)**

3.4 How long ago did you last smoke cigarettes fairly regularly?

(381-382) __ __ years

00 = less than 1 year **(GO TO 3.5)**
77 = never smoked cigarettes regularly **(GO TO 3.7)**
88 = refused **(GO TO 3.7)**
99 = don't know

3.5 During the period when you were smoking, about how many cigarettes a day did you smoke?

(383-384) __ __ cigarettes per day
88 = refused
99 = don't know

3.6 About how old were you when you first started smoking cigarettes fairly regularly?

(385-386) __ __ years old
88 = refused
89 = never smoked cigarettes fairly regularly
99 = don't know

PARTICIPANT ID ___ ___ ___ ___

3.7 Have you ever used any of the following tobacco products?

3.7.1 **Cigars**

(387)

1 = yes
2 = no **(GO TO 3.7.2)**
8 = refused to answer **(GO TO 3.7.2)**
9 = don't know **(GO TO 3.7.2)**

3.7.1.2 During the period when you smoked cigars the most, about how many cigars a day did you smoke?

(388-389) ___ ___ cigars per day
00 = less than 1
88 = refused to answer **(GO TO 3.7.2)**
99 = don't know **(GO TO 3.7.2)**

3.7.2 **Pipe**

(390) 1 = yes
2 = no **(GO TO 3.7.3)**
8 = refused to answer **(GO TO 3.7.3)**
9 = don't know **(GO TO 3.7.3)**

3.7.2.1 During the period when you smoked a pipe the most, about how many bowls of tobacco did you smoke per day?

(391-392) ___ ___ bowls per day
88 = refused to answer
99 = don't know

3.7.3 **Chewing tobacco or snuff**

(393) 1 = yes
2 = no **(GO TO 3.8)**
8 = refused to answer **(GO TO 3.8)**
9 = don't know **(GO TO 3.8)**

3.7.4 During the time that you used snuff or chewed tobacco the most, about how many times per day did you use it?

(394-395) ___ ___ times per day
88 = refused to answer
99 = don't know

3.8 Did you **ever** drink **alcoholic beverages**, including beer, wine or wine coolers, liquor, or AVA (moonshine)?

(396) 1 = yes
2 = no **(GO TO 4.1)**
8 = refused **(GO TO 4.1)**
9 = don't know **(GO TO 4.1)**

PARTICIPANT ID ___ ___ ___ ___

3.8.1 How old were you when you began drinking alcoholic beverages at least once a week?

(397-398) ___ ___ years old
00 = never drank alcoholic beverages as often as once a week **(GO TO 4.1)**
88 = refused to answer
99 = don't know

3.8.2 Do you presently drink alcoholic beverages at least once per week?

(399) 1 = yes **(GO TO 3.8.2.2)**
2 = no **(GO TO 3.8.2.1)**
8 = refused to answer **(GO TO 4.1)**
9 = don't know **(GO TO 4.1)**

3.8.2.1 How old were you when you quit?

(400-401) ___ ___ **(GO TO 4.1)**
88 = refused to answer **(GO TO 4.1)**
99 = don't know **(GO TO 4.1)**

3.8.2.2 On the average, **how many drinks a week** do you have?
(1 DRINK = 1 BEER, 1 SHOT LIQUOR, 1 GLASS WINE OR WINE COOLER)
(1 large Vailima beer = 2 Drinks)

(402-403) ___ ___
00 = less than one per week
88 = refused to answer

SECTION IV WOMENS REPRODUCTIVE HISTORY

QUESTIONS **4.1-4.3** ARE FOR **FEMALES** 15 YEARS OF AGE AND OLDER
FOR ALL OTHERS, GO TO QUESTION 5.1

The next set of questions are about pregnancy.

4.1 Are you now pregnant?

(404) 1 = yes
2 = no
8 = refused
9 = don't know

4.2 Have you **ever** been pregnant?

(405) 1 = yes
2 = no **(GO TO 5.1)**
8 = refused **(GO TO 5.1)**
9 = don't know **(GO TO 5.1)**

4.3 What is the **total** number of **times** in your life that you have been **pregnant?** Count your current pregnancy if you are now pregnant and count all other pregnancies, including livebirths, stillbirths, miscarriages, or abortions.

(406-407) __ __ total pregnancies lifetime
88 = refused
99 = don't know

SECTION V DIETARY

Now I'd like to ask you some questions about your diet and food preparation at home:

5.1 When food or drinks are prepared, served, or stored, are they often placed in **clay pottery or ceramic** dishes?

(408) 1 = Yes
2 = No
9 = DON'T KNOW

5.2 When food or drinks are prepared, served, or stored, are they often placed in **copper or pewter** dishes or containers?

(409) 1 = Yes
2 = No
9 = DON'T KNOW

5.3 When food is stored or put away, is it sometimes **stored in the original can** after being opened?

(410) 1 = Yes
2 = No

THE NEXT QUESTION IS FOR CHILDREN 8-12 YEARS
ALL OTHERS SKIP TO 6.1

5.4 Sometimes children put things in their mouth other than food. How often does (CHILD'S NAME) **put things other** than food in his/her mouth?

(411) 1 = Does this a lot
2 = Just once in a while
3 = Almost never
4 = Never
9 = DON'T KNOW

(412-435) IF YES, SPECIFY ______________________________

The next series of questions are about eating fish; including fresh fish, frozen fish, can fish or shellfish.

6.1 Which of the following best describes how often you ate fish; fresh, frozen, can fish or shellfish, **LAST MONTH?**

(436) **Did not eat fish last month.** (Go to 6.4) ___

Ate fish less than once a week. (Go to 6.2) ___

Ate fish about once a week. (Go to 6.2) ___

Ate fish more than once a week. (Go to 6.2) ___

PARTICIPANT ID ___ ___ ___ ___

6.2 Approximately how many meals of fish did you (OR SUBJECT) eat per week **LAST MONTH?**

(437-438) __.__ (e.g. .5, 1.0.,2.0.,3.0 etc)

6.3 I am now going to read a list of types of fish to you. Please tell me which of these you (OR SUBJECT) ate **LAST MONTH?**

	Common Name	Samoan Name	Circle YES	NO	DK
(439)	**Surgeon Fish**	Palagi, Alogo, Poge,	1	2	9
(440)	**Jacks**	Lupo, Ulua	1	2	9
(441)	**Groupers**	Gatala, Mata'ele, Gatalauli	1	2	9
(442)	**Snappers**	Tamala, Ta'iva, Mala'i	1	2	9
(443)	**Parrotfish**	Fuga, Laea	1	2	9
(444)	**Mullet**	Anae, Fuafua	1	2	9
(445)	**Squirrel Fish**	Malau	1	2	9
(446)	**Big-Eye Scad**	Atule	1	2	9
(447)	**Invertebrates** (e.g. Octopus, snails, clams, crabs, urchins, cucumbers, oysters, etc)	Fe'e, Palolo, Tuitui, Pule, Vaga, Sea, Lole, Mama'o, Gau, Ula, Alili, ali'ali, Ofaofa Pipi, Matamalu, Uga, Pa'a	1	2	9
(448)	**Other local catch**	e.g. Tugane clams	1	2	9

(449-489) **Please name** _(print)_________________________

(490)	**Frozen fish**		1	2	9
(491)	**Canned fish**		1	2	9

6.4 Did **YOU CATCH** fish **LAST MONTH?**

(491) 1 = Yes
2 = No **(GO TO 7.1)**

Now I would like to determine where you **USUALLY** caught or bought fish. Please use the list to tell where you **USUALLY** got the fish.

6.5 Where did you usually **CATCH** fish **LAST MONTH?**

(492-493) ____

PARTICIPANT ID ___ ___ ___ ___

(494-544) Other, please specify ______________________________

LOCATION CODES

01 = Inner Pago Pago Harbor
02 = Outer Pago Pago Harbor
03 = Market place in Fagatogo **BEFORE** Hurricane Val
04 = Market place in Fagatogo **AFTER** Hurricane Val
05 = Grocery Store around inner harbor
06 = Around Ta'U Village
07 = Around Faleasao village
08 = Around Fitiutu village
09 = Other, Please Specify ______________________________

7.1 Hurricane Val hit Samoa in December 1991. Which of the following best describes how often you (OR SUBJECT) ate fish **ONE MONTH BEFORE** Hurricane Val, in November 1991?

(545)	**Did not eat fish?**	(GO TO 7.4)	____
	Ate fish less than once a week?	(GO TO 7.2)	____
	Ate fish about once a week?	(GO TO 7.2)	____
	Ate fish more than once a week?	(GO TO 7.2)	____

7.2 Approximately how many meals of fish did you (OR SUBJECT) eat per week **one month before** Hurricane Val?

(546-547) __ __

7.3 I am going to read the same list of types of fish to you. Please tell me which of these you (OR SUBJECT) ate **ONE MONTH BEFORE** Hurricane Val **(during the entire month of November 1991)**.

Common Name	Samoan Name	Circle YES	NO	DK
(548) **Surgeon Fish**	Palagi, Alogo, Poge,	1	2	9
(549) **Jacks**	Lupo, Ulua	1	2	9
(550) **Groupers**	Gatala, Mata'ele, Gatalauli	1	2	9
(551) **Snappers**	Tamala, Ta'iva, Mala'i	1	2	9
(552) **Parrotfish**	Fuga, Laea	1	2	9
(553) **Mullet**	Anae, Fuafua	1	2	9
(554) **Squirrel Fish**	Malau	1	2	9
(556) **Big-Eye Scad**	Atule	1	2	9

PARTICIPANT ID ___ ___ ___ ___

(557)	**Invertebrates** (e.g. Octopus, snails, clams, crabs, urchins, cucumbers, oysters,)	Fe'e, Palolo, Tuitui, Pule, Vaga, Sea, Lole, Mama'o, Gau, Ula, Alili, ali'ali, Ofaofa Pipi, Matamalu, Uga, Pa'a	1	2	9
(558)	**Other local catch**	e.g. Tugane Clams	1	2	9

(559-609) **Please name** (print) ________________________________

(610)	**Frozen fish**	1	2	9
(611)	**Canned fish**	1	2	9

7.4 Did you **CATCH** fish **ONE MONTH BEFORE** Hurricane Val?

(612) 1 = Yes
2 = No **(GO TO 7.6)**

7.5 Where did you **USUALLY CATCH** fish **ONE MONTH BEFORE** Hurricane Val? (See location code list below)

(613-614) ____

(615-655) OTHER, please specify ________________________________

LOCATION CODES

01 = Inner Pago Pago Harbor
02 = Outer Pago Pago Harbor
03 = Market place in Fagatogo **BEFORE** Hurricane Val
04 = Market place in Fagatogo **AFTER** Hurricane Val
05 = Grocery Store around inner harbor
06 = Around Ta'U Village
07 = Around Faleasao Village
08 = Around Fitiutu Village
09 = Other, Please specify ________________________________

7.6 Was fish bought or purchased to be eaten by members of the household the **MONTH BEFORE** Hurricane Val?

(656) 1 = Yes
2 = No **(GO TO 7.8)**

7.7 Where was fish usually bought or purchased to be eaten by members of the household **ONE MONTH BEFORE** Hurricane Val?

(657-658) _____

(659-689) Other, please specify ________________________________

PARTICIPANT ID ___ ___ ___ ___

INTERVIEWER: USE CODE LIST TO FILL IN LOCATION WHERE FISH WERE OBTAINED.

LOCATION CODES

01 = Inner Pago Pago Harbor
02 = Outer Pago Pago Harbor
03 = Market place in Fagatogo **BEFORE** Hurricane Val
04 = Market place in Fagatogo **AFTER** Hurricane Val
05 = Grocery Store around inner harbor
06 = Around Ta'U Village
07 = Around Faleasao Village
08 = Around Fitiuta Village
09 = Other, Please Specify ________________________________

7.8 Now I would like to ask a few questions similar to the questions just asked to determine how often you (OR SUBJECT) ate fish **6 MONTHS AGO**. Have you eaten **ANY** fresh, frozen or canned fish in the last 6 months?

(690)
1 = Yes
2 = No **(GO TO 7.9.2)**

7.9 **If** my hand represents about 3 ounces of fish, looking at my hand, about how much fish this size would you usually eat in a average meal?

(691-693) __ __.__ (e.g. .5 = 1/2 hand or 1/2 fish, 1.0 = 1 fish, 2.0, 3.0, etc)

7.9.1 How often does your family usually gut and clean fish before eating?

(694-695)
01 = Usually gut and clean fish before eating
02 = Just once in a while
03 = Almost never
04 = Never
05 = DON'T KNOW

7.9.2 Did you know that there is a **health advisory** for Pago Pago Harbor because of contamination that advises people not to eat fish from the inner Pago Pago Harbor and to always clean fish from the outer Pago Pago Harbor?

(696)
1 = Yes
2 = No

7.9.3 Have you changed your fishing habits or the amount or types of fish that you eat from the **harbor?**

(697)
1 = Yes
2 = No (GO TO 7.9.6)

7.9.4 Was this due to the health advisory?

(698)
1 = Yes
2 = No

PARTICIPANT ID ___ ___ ___ ___

7.9.5 What other reasons have changed these habits:

(699-739) (print) ______________________________________

7.9.6 Are you concerned about contamination of fish with heavy metals from the inner Pago Pago Harbor?

(740)
1 = Yes
2 = No (GO TO 8.1)

7.9.7 What other contaminants are you concerned about in fish from the harbor?

(741-791) (print) ______________________________

SECTION VI HOBBIES/OCCUPATIONS

The next set of questions are about jobs YOU may have or have had.

8.1 Have **YOU** ever **worked** in a fish cannery?

(792)
1 = Yes
2 = No (GO TO 8.3)
9 = DON'T KNOW (GO TO 8.3)

8.2 What type of cannery work did YOU do in the last 90 days? **(Circle all that apply.)**

		Yes	No	UNKNOWN
(793)	a. Cleaning fish	1	2	9
(794)	b. packaging fish	1	2	9
(795)	c. Soldering Cans	1	2	9
(796)	d. Transportation/ handling	1	2	9
(797)	e. Clerical/Admin.	1	2	9
(798)	f. Other	1	2	9

(799-840)
IF OTHER, specify: ______________________________

8.3 What is the **name of the place** where **YOU** work (have worked)?

(841-891) (print) ______________________________________

8.4 How **long have YOU worked** (did you work) there, in years? (3 months = .3; 6 months= .5; 9 months= .8)

(892-894) ___ ___ . ___ Years (if 00 skip to 9.1)

PARTICIPANT ID ___ ___ ___ ___

8.5 Now I'd like to ask about your **two most recent jobs**, starting with the present. (Unemployed or retired or housewife should be entered as a job.)

a. What is your current job/where did you work before?
b. What type of industry is/was this?
c. What is/was your job title and a description of what you do?
d. When did you start working there?

8.6

a. JOBS	b. TYPE OF INDUSTRY	c. TITLE	d. FROM	e. TO
(895-935)	(936-976)	(977-1017)	(1018-1021)	(1022-1025)
________	________	________	__ __/__ __	__ __/__ __
________	________	________	__ __/__ __	__ __/__ __
(1026-1066)	(1067-1107)	(1108-1148)	(1149-1152) Month/year	(1153-1156) Month/year

8.7 What is the job title you have had **most** of the time you have worked in the last 90 days?

(1157-1207) (print) ____________________

8.8 What is the job title you have had **most** of the time you have worked in the last year?

(1208-1258) (print) ____________________

Now I'd like to ask you some questions about the work and hobbies of ALL persons living in your home.

9.1 In the last 90 days have YOU DONE any painting, soldering, welding, machinist work, or radiator repair as a HOBBY?

1 = Yes
2 = No
3 = DON'T KNOW

9.1.1 In the last 90 days have ANY OTHER members of your household, not including yourself, done any painting, soldering, welding, machinist work, or radiator repair as a **HOBBY**?

(1259)
1 = Yes
2 = No
9 = DON'T KNOW

9.2. In the last 90 days have YOU WORKED on a job as a painter, solderer, welder, machinist, or repaired radiators?

1 = Yes
2 = No
3 = DON'T KNOW

PARTICIPANT ID ___ ___ ___ ___

9.2.1 In the last 90 days have any members of your household, not including yourself, **WORKED** on a job as a painter, solderer, welder, machinist, or repaired radiators?

(1260)
1 = Yes
2 = No
9 =DON'T KNOW

9.3 Have **ANY** members of your household, not including yourself, worked in a tuna cannery or related fishing industry job in the last 90 days?

(1261)
1 = Yes
2 = No (GO TO 9.5)
9 = DON'T KNOW

9.4 What **type of cannery or fishing related work** have other household members done in the last 90 days? (Circle all that apply.)

			Yes	No	UNKNOWN
(1262)	a.	Cleaning fish	1	2	9
(1263)	b.	packaging fish	1	2	9
(1264)	c.	Soldering Cans	1	2	9
(1265)	d.	Transportation/ handling	1	2	9
(1266)	e.	Clerical/Admin.	1	2	9
(1267)	f.	Other	1	2	9

(1268-1318) **IF OTHER, SPECIFY:** (print) ________________________________

9.5 The last question I need to ask you concerns your **total household income** before taxes. Please tell me which of the following five income groups best describes your total household income before taxes:

(1319)
1 = less than $5,000 per year

2 = $5,000 to $9,999 per year

3 = $10,000 to $14,999 per year

4 = $15,000 to $19,999 per year

5 = more than $20,000 per year

8 = refuse to answer

9 = don't know

PARTICIPANT ID ___ ___ ___ ___

9.6 What is the highest year of education you have completed? (circle one)

(1320-1322)

No Schooling	000
Elementary Schooling	001 002 003 004 005 006 007 008
High School	009 010 011 012
Technical or Trade School	513 514
Junior or Community College	613 614
Four year College or University	013 014 015 016
Graduate School (or higher)	017
Refused to answer	888
Don't know	999

9.7 Have you **ever seen this questionnaire** before today's interview?

(1323)
1 = yes
2 = no
8 = refuse
9 = don't know

The second part of the study is a blood and urine sample that will be used to measure your exposure to chemicals. We are setting up appointments at (name the location). We can schedule your appointment on Monday through Friday. Which time would be best for you ?

Day: _____ Date: __ __/__ __/__ __ Time: __ __:__ __ __AM __PM
month day year

Please remember, do not eat ANY type of fish, including fresh or frozen fish such as fish sticks, or canned fish such as tuna fish during the 2 days before your medical appointment. This is because we want the levels of metals if present in your blood to represent fish that you have eaten for the past few months. During the 2 days immediately after we eat fish, the levels of metals in our blood may be higher than usual. It takes about 2 days for certain metals to level off.

THIS IS THE END OF THE INTERVIEW. DO YOU HAVE ANY QUESTIONS?
THANK YOU FOR YOUR TIME AND PATIENCE! HAVE A GREAT DAY!

PARTICIPANT ID ___ ___ ___ ___

INTERVIEWER: Complete below before turning in the interview.

Time the interview ended
__ __:__ __

Total interview time
__ __:__ __ minutes

The following will be completed at the time of medical appointment.

10.1 Weigh the participant and enter weight: __ __ __.__ lbs

(1324-1327)

THE NEXT TWO QUESTIONS WILL ONLY BE ASKED ON THE DAY OF BLOOD AND URINE COLLECTION.

10.2 Have **YOU (OR SUBJECT) eaten any fish**, including any canned fish such as tuna, salmon, or sardines, or any fresh or frozen fish, within the **last 2 days (prior to specimen collection)**?

(1328) Yes___ 1 No___ 2

10.3 What type of fish have you eaten in the last 2 days **(prior to specimen collection)**? (Use list at Qst. 6.3)

(1329-1379) (print)____

Appendix I—A Comparison of Shoreline Catches by Species, ASDMWR, 1991

Annual shoreline catch by species, excluding atule, within the study area. Shellfish weights include shells

FISH NAMES SAMOAN	 COMMON	 SCIENTIFIC	POUNDS LANDED IN STUDY AREA	PERCENT OF TOTAL FISH	PERCENT OF GRAND TOTAL
Atule	Big-eye scad	*Selar crumenophthalmus*	EXCLUDED	EXCLUDED	EXCLUDED
Lupo, ulua	Jacks	Carangidae	14655	23	17
Anae, fuafua	Mullet	Mugilidae	9886	16	12
Palagi	Yellow surgeonfish	*Acanthurus xanthopterus*	5996 *	10	7
Alogo	Lined surgeonfish	*Acanthurus lineatus*	4054 *	6	5
Gatala	Groupers	Serranidae	2870	5	3
Malau	Squirrelfish	Holocentridae	2789 *	4	3
Foge	Surgeonfish	Acanthuridae	2152 *	3	3
Atuleau	Mackerel scad	*Decapterus macrosoma*	2012	3	2
Ga	Mackerel	Rastrelliger spp.	1667	3	2
Fuga, laea	Parrotfish	*Scaridae*	1618 *	3	2
Pusi gatala	Spotted eels	*Gymnothorax spp.*	1298	2	2
Manini	Convict tang	Acanthurus triostegus	1200 *	2	1
Pa'u malo	Filefish	Monacanthidae	1161	2	1
Sapatu	Barracuda	*Sphyraena spp.*	1009	2	1
Afulu	Yellowstripe goatfish	*Mulloides flavolineatus*	797	1	1
Tamala	Flametail snapper	*Lutjanus fulvus*	735	1	<1
I'asina	Yellowfin goatfish	*Mulloides vanicolensis*	666	<1	<1
Lai, tavai	Letherback	*Scomberoides lysan*	610	<1	<1
Lalafutu	Pompano	*Trachinotus spp.*	600	<1	<1
Ta'iva	Onespot snapper	Lutjanus monostigmus	566	<1	<1
Sugale	Wrasses	Labridae	539	<1	<1
Mata'ele	Flagtail grouper	*Cephalopholis urodeta*	530	<1	<1
Tu'u'u	Angels, damselfish	Pomacanthidae, Pomacentridae	489	<1	<1
Filoa, mata'ele ele	Emperors	Lethrinidae	477	<1	<1
Lo	Rabbit fish	Siganidae	458	<1	<1
Gatalauli	Peacock grouper	*Cephalopholis argus*	417	<1	<1
Nanue, ganue	Rudderfish	Kyphosidae	346	<1	<1
Kavakava, atu o	Little tuna	*Euthynnus affinis*	298	<1	<1
Tautu	Porcupine fish	*Diodon spp.*	284	<1	<1
Pelupelu	Herrings	*Clupeidae*	265	<1	<1
Tagi	Dogtooth tuna	*Gymnosarda unicolor*	252	<1	<1
Mala'i	Paddletail snapper	Lutjanus gibbus	247	<1	<1
Sumu, molua	Triggerfish	Balistidae	235	<1	<1
I'aui	Conger eels	Congridae	224	<1	<1
Papa, velo	Lunartail grouper	*Variola louti*	175	<1	<1
Ta'uleia	Indian goatfish	*Parupeneus indicus*	122	<1	<1
Tolai, mumu	Yellowspt emperor	*Gnathodentex aureolineatus*	120	<1	<1
Malie	Sharks	Chondrichthyes	104	<1	<1
Tifitifi	Butterflyfish	Chaetodontidae	102	<1	<1
Gofu	Scorpionfish	Scorpaenidae	90	<1	<1
Ume, ili, ili'ilia	Unicornfish	*Naso spp.*	86	<1	<1
Safole, sesele	Mountain bass	Kuhlia spp.	85	<1	<1
Unident. finfish			81	<1	<1
Lalafi, malakea	Wrasses	*Cheilinus spp.*	73	<1	<1
Matu	Mojarras	*Gerres spp.*	70	<1	<1
Ava'ava	Terapon perch	*Terapon jarbua*	69	<1	<1
Ise, a'u	Needlefish	Belonidae	50	<1	<1
Sue	Pufferfish	Tetradontidae	40	<1	<1
Mumu	Ponyfish	Leiognathidae	30	<1	<1
Maogo	Whitespotted surgeonfish	*Acanthurus guttatus*	27 *	<1	<1
Mutu,Mamo	Seargent major	*Abudefduf saxatilis*	26	<1	<1
Moamoa	Trunkfish	Ostraciidae	12	<1	<1
Fo	Cardinalfish	Apogonidae	9	<1	<1
Tacto, tactao	Lizzardfish	Synodontidae	3	<1	<1
I'usina, laulama	Surgeonfish	*Acanthurus glaucopareius*	2 *	<1	<1
		Total Fish	62787	100	75

(con't next page)

INVERTEBRATE NAMES SAMOAN	COMMON	SCIENTIFIC	POUNDS LANDED IN STUDY AREA	PERCENT OF TOTAL INVERTEBRATES	PERCENT OF GRAND TOTAL
Fe'e	Octopus	*Octopus spp.*	8380	39	10
Palolo	Palolo	*Eunice viridis*	3446	16	4
Tuitui	Sea urchin	Echinometra	3261	15	4
Pule, sisi	Seashells	Gastropoda	2331	11	3
Vaga	Sea urchin	Echinoids	1192	6	1
Sea,lole mam [illegible] gau	Sea cucumbers	Holothuroidea	1163	5	1
Ula	Spiny lobsters	*Panulirus penicillatus*	612	3	<1
Alili, ali'ali	Turban snail	*Turbo chrysostomus*	472	2	<1
Ofaofa	Heart urchin	Spatangoids	193	1	<1
Pipi	Clam	Bivalvia	129	1	<1
Ma'amalu	Sea anenome	Anthozoa	128	1	<1
Uga	Hermit crab	*Coebites spp.*	81	<1	<1
Pa'a	Crab	Crustacea	21	<1	<1
		Total Invertebrate	21459	100	25
		GRAND TOTAL	84246	100	100

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* Denotes likely underestimate due to being harvested primarily by night divers (see text).

Appendix J—Specimen Collection and Shipping Protocol

AMERICAN SAMOA METAL EXPOSURE STUDY

STUDY # 92-0017

SPECIMEN COLLECTION AND SHIPPING PROTOCOL

Division of Environmental Health Laboratory Sciences
Center for Environmental Health and Injury Control
Centers for Disease Control and Prevention
Atlanta, Georgia 30333

Prepared: 4/1/91
Revised: 6/4/92

I. INTRODUCTION page 3

II. URINE COLLECTION AND PROCESSING page 4-6

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A. COLLECTION PROCEDURE page 8-9

B. PROCESSING PROCEDURE page 9

IV. SHIPMENT OF SPECIMENS page 10-13

A. BEGINNING OF STUDY AND GENERAL INSTRUCTIONS page 10

B. SPECIMEN SHIPPING LIST page 10

C. SPECIMEN PACKING AND SHIPPING page 11-13

V. SPECIMEN TESTS page 14

VI. FLOW CHARTS page 15-16

A. URINE COLLECTION AND PROCESSING PROTOCOL page 15

B. WHOLE BLOOD COLLECTION AND PROCESSING PROTOCOL page 16

I. INTRODUCTION

The proper collection, processing, storage and shipment of physiologic specimens from participants in the American Samoa Metal Exposure Study is critical to the success of the study. The following sections describe the procedures which must be followed for all specimen collections. These procedures must be strictly adhered to in order to avoid contamination, loss, or degradation of the specimens. Please familiarize yourself with the study protocol and insure that you understand the concept of the study, the role of all the personnel involved, and your own role.

Note that subjects are not required to report for blood and urine collection in a fasting state although blood and urine collection should be accomplished early in the visit to avoid discomfort to the subject. Blood and urine collection must be completed and processed under carefully controlled conditions of good laboratory practice. Blood separation and processing must be accomplished promptly to avoid degradation of the specimen.

It is extremely important that all records associated with each subject be maintained in an organized and complete manner to ensure that all information is properly collected and accurate. Specimens should be labeled promptly and processed as a unit or "run" and precautions must be taken to avoid patient-specimen-label-record mix-ups. This type of error is usually the most common error in the laboratory setting, but careful planning and a well organized work area will keep such errors at a minimum. Some of the information required for the specimen label and shipping list will be collected at the time of specimen collection. Problems in blood and/or urine collection should be noted in the sample log and in the comments section of the shipping list.

II. URINE COLLECTION AND PROCESSING (SEE PROTOCOL FLOWCHART ON PAGE 15)

A. COLLECTION PROCEDURE

1. Materials needed per participant.

- Urine collection cup (250 mL. plastic, sterile)
- Preprinted label

2. Preparation of urine collection cup for participant.

- Remove the collection cup with the cap in place from its plastic wrapping being careful not to dislodge the cap or touch the inside of the container or cap.

- With the cap securely attached to the container affix the participant's preprinted label marked "URINE CONTAINER" to the urine specimen cup.

3. Instructions for urine collection.

- The following instructions should be explained to the participant prior to urine collection:

. Hands should be washed with soap and water.

. The collection cup should not be opened until just before voiding.

. The person should leave the cap turned up while voiding, then recap the filled container immediately.

. It is most important that the inside of the container and the cap not be touched or come into contact with any parts of the body or clothing or external surfaces. Exposure to air should be minimized.

. The participant should deliver the capped specimen immediately to the clinic personnel.

B. PROCESSING PROCEDURE (SEE FLOW CHART ON PAGE 15)

1. Materials and equipment needed per participant.

-15 mL Conical-bottom plastic tube with ORANGE cap (containing triton-x and sulfamic acid as preservative for URINE MERCRUY)
-15 mL Conical-bottom plastic tube with BLUE cap for URINE METALS
- 6 mL Plastic tube with white cap for URINE CREATININE
-Powder-free lab gloves
-Safety glasses
-Lab apron
-Laboratory hood
-Racks
-Deionized water (for preparing lab blanks)
-Ultrapure concentrated nitric acid (G. Frederick Smith Chemical Co., Columbus, Ohio 43223, Catalogue No. 63, ultrex grade, or equivalent)
-Pipettor (Gilson Pipetman or other precision adjustable pipettor capable of dispensing 100 uL:Biorad BR-33 clear (metal-free) disposable pipet tips capable of containing 100 uL equivalent)
-Preprinted labels
-Freezer (-20°C)

2. Special safety precautions.

Nitric Acid - Special care should be taken when handling and dispensing the concentrated acid, since it is a caustic chemical capable of severe eye or skin damage. Wear a lab apron, powder-free gloves, and safety glasses. If the nitric acid comes in contact with any part of the body, quickly wash with copious quantities of water for at least 15 minutes

3. Processing (urine specimen)

- Wear powder-free lab gloves, safety glasses, and work under a laboratory hood, if available.

- Using the preprinted labels provided for each participant, add the date collected and the initials of the person preparing the aliquots and label each of the plastic tubes as follows:

Priority	Size/Type Bottle	Bottle Label
1.	15 mL ORANGE capped plastic	92-0017-0001-T1 "URINE MERCURY"
2.	15 mL BLUE capped plastic	92-0017-0001-T2 "URINE METALS"
3.	6 mL WHITE capped plastic	92-0017-0001-U1 "URINE CREATININE"

- Gently swirl the specimen in the capped collection container to resuspend any solids.

- The ORANGE capped tube for "URINE MERCURY" should be filled to the 10 mL mark. THIS TUBE MUST BE EXACT AS TO THE AMOUNT OF URINE ADDED TO ENSURE THE PROPER RATIO OF URINE TO PRESERVATIVE.

- The BLUE capped tube for "URINE METALS" should have urine poured to the 10 mL mark. Concentrated nitric acid will be added later as a preservative.

- The WHITE capped tube should contain at least 1 mL of urine and as much as 5 mL but don't overfill since the urine will expand while freezing and may cause the cap to pop off.

- Recap and tightly seal the ORANGE capped tube and the WHITE capped tube.

- Dissolve the preservative in the ORANGE capped tube for "URINE MERCURY" by gently mixing 5-10 times on a mixer or by gently inverting the tube by hand.

4. Preparation of laboratory blanks

- Wearing protective clothing and working under a hood, prepare one laboratory blank for "URINE MERCURY" and "URINE METALS" each day on which urine specimens are collected.

- Select one of the 15 mL ORANGE capped plastic tubes with preservative already added and slowly add deionized water to the 10 mL line. Mix well and add a label printed for "URINE MERCURY LAB BLANK" and add the date on which it was prepared.

- Select one of the 15 mL BLUE capped plastic tubes and add deionized water to the 10 mL line. Then carefully aliquot 100 uL of nitric acid at the same time it is added to the urine specimens (SEE BELOW FOR INSTRUCTIONS). Cap, label with the preprinted label "URINE METALS LAB BLANK" and invert the tube five times.

5. Addition of acid preservatives.

Addition of nitric acid to metals tubes.

NOTE: RINSE OUTSIDE OF PIPET TIP WITH DISTILLED WATER BEFORE USE.

- While working under a hood and wearing protective unpowdered gloves, apron and safety glasses, use a pipettor to rinse a pipet tip with nitric acid. Using the same tip, aliquot 100 uL into each of the 15 mL conical-bottom tubes containing the participant's urine which will be used for metals analyses. Process one tube at a time, removing the cap, adding the acid, and replacing and tightly screwing the cap. Do not touch the interior of the cap or tube or place the cap or pipet tip on external surfaces which may be contaminated for trace elements. Change the tip each time it becomes contaminated. Invert the tubes gently 5 times and freeze immediately at -20°C.

6. Tests done at the field site.

- A urine specific gravity will be done on all samples from the collection cup after aliquots have been made. This is done by placing a drop of urine into the space on the urinometer and looking through the viewing chamber. Make a log of the specific gravity reading on the inventory shipping list.

III. WHOLE BLOOD COLLECTION AND PROCESSING (See flowchart on page 16)

A. COLLECTION PROCEDURE

1. Materials needed per participant.

-Gauze sponges
-Alcohol wipe
-Bandaid
-3 mL purple top tube
-21g 3/4" butterfly assembly with multiple sample luer adapter, sterile
-23g 3/4" butterfly assembly with multiple sample luer adapter for children and difficult sticks.
-21g or 22g Vacutainer multiple sample needles
-10 cc plastic syringe for children
-Preprinted labels
-Tourniquet
-Vacutainer holder and adapters for pediatric tubes
-Refrigerator
-White storage boxes

2. Venipuncture procedure.

-Locate a suitable table and chair for blood collecting and lay out blood collection supplies.

-Locate the puncture site. Hold with 2 fingers on one side of the "alcohol wipe" so that only the other side touches the puncture site. Wipe the area in a circular motion beginning with a narrow radius and moving outward so as not to cross over the area already cleaned. Repeat with a second alcohol wipe.

-Locate vein and cleanse in manner previously described, then apply the tourniquet. If it is necessary to feel the vein again, do so; but after you feel it, cleanse with alcohol prep again, and dry with a sterile gauze square.

-Fix the vein by pressing down on the vein about 1 inch below the proposed point of entry into the skin and pull the skin taut.

-Approach the vein in the same direction the vein is running, holding the needle so that a 15° angle with the examinee's arm.

-Push the needle, with bevel facing up, firmly and deliberately into the vein. Activate the vacuum collection tube. If the needle is in the vein, blood will flow freely into the tube. If no blood enters the tube, probe for the vein until entry is indicated by blood flowing into the tube.

-For collection, loosen the tourniquet immediately after blood flow is established and release entirely as the last tube fills. Collect 1 purple top tube (3mL).

-If a syringe is required to obtain the blood, attach it to the appropriate size butterfly needle and withdraw 2-3 mLs blood. After withdrawing the needle from the arm, quickly change the needle on the syringe and transfer the blood from the syringe by puncturing the top of the purple-top tube with the new needle and allowing the vacuum to draw the blood into the tube. Mix well with the anticoagulant.

-When the needle is out of the arm, press gauze firmly on the puncture. Heavy pressure as the needle is being withdrawn should be avoided because it may cause the sharp point of the needle to cut the vein.

-Have the examinee raise his arm (not bend it) and continue to hold the gauze in place for several minutes. This will help prevent hematomas.

-Report to the physician any reaction experienced by the participant during the venipuncture procedure.

-Label all tubes with the preprinted labels provided, and use a ballpoint pen to add the date collected and your initials to the label. The tubes should be affixed with the label showing the participant's ID number (e.g.92-0017-0001-B1).

-Place a bandaid on the subject's arm.

B. WHOLE BLOOD PROCESSING PROCEDURE (SEE FLOWCHART ON PAGE 16)

1. The purple-top tube should be labelled for BLOOD LEAD/MERCURY and placed in a white storage box and kept in the refrigerator until shipment to CDC.

IV. SHIPMENT OF SPECIMENS TO CDC, ATLANTA, GA.

A. BEGINNING OF STUDY AND GENERAL INSTRUCTIONS

1. Determine the times 'FEDERAL EXPRESS' packages are picked up in order to connect with the best flights to Atlanta, Georgia provided the specimens are to shipped there. If Federal Express is not used as the overnight carrier, then schedules for package pick-up should be established at the outset of the study with the carrier that is selected. If a contractor is used to coordinate collection and shipment of specimens, they will provide this information.

2. Specimens collected in this study will be shipped at the end of the study. Once the collection schedule for the study has been established, shipment of specimens can be arranged.

3. Inquire about regulations in your area concerning shipment of human blood, serum, and urine specimens with dry ice and the quantity of dry ice allowed per shipper. Also, make sure the specimens will be received at CDC within 24 hours if possible.

4. For specimens that should be shipped frozen: Schedule a delivery of dry ice from a local supplier for shipping specimens. A block should be sawed at the plant into 1" slabs. Then each of these should be sawed lengthwise. A 7"x10" slab would fit easily into the shipper without having to break the slab. (Large pieces are preferable to small chunks, since they do not volatilize as rapidly.)

5. For all shipments, do not pack shippers with frozen specimens and dry ice until just before shipment.

6. Telephone the laboratory at CDC the day the shipment is mailed at (404) 488-4305. Speak with Charles Dodson.

B. SPECIMEN SHIPPING LIST

1. For each shipment, fill out a blank Specimen Shipping List provided by CDC. If the number of specimens in a shipment is too large to fit on one page, please use the continuation sheets provided. Please give the following information on the blank shipping lists (See attached example of a completed Specimen Shipping Lists):

a. Page number - e.g. 1 of 4.
b. Shipment Number- number shipments sequentially starting with 1.
c. Number of shippers- total number of shippers containing frozen, refrigerated or unrefrigerated serum and urine specimens which are being mailed in this shipment.
d. Type of Specimens- whole blood, serum, or urine.
e. Number of Specimens- number of each type of specimen shipped.
f. Name, Title, Signature, and Phone Number of person sending shipment or initials as indicated on the continuation sheets.
g. Date shipped.
h. Specimen ID for each participant- (e.g. 92-0017-0001). For each participant, check (X) each individual specimen type/aliquot included in this shipment.
i. Date Collected- e.g. 01-25-92.
j. Comments- Specify any deviations from collection, storage, and shipment protocols, and date of occurrence.

Photocopy 2 extra copies of the completed shipping list. As will be described again later, the original will be shipped with the specimens, a copy mailed to CDC under separate cover, and a copy retained for your records.

C. FROZEN AND REFRIGERATED SPECIMEN PACKING

1. Materials needed per shipper

-1 styrofoam shipper
-10-12 lbs dry ice FOR FROZEN SPECIMENS ONLY
-Frozen ice packs FOR REFRIGERATED SPECIMENS ONLY
-Freezer boxes
-Safety glasses or eye shield
-Strapping tape
-Gloves for handling dry ice and frozen specimens
-Sheets of bubble-pack packing material
-'FEDERAL EXPRESS' label, preaddressed by Centers for Disease Control personnel
-DRY ICE label FOR FROZEN SPECIMENS ONLY
-KEEP REFRIGERATED label FOR REFRIGERATED SPECIMENS ONLY
-HUMAN BLOOD-THIS SIDE UP label
-CDC 'Specimen Shipping List' (completed)
-Zip-lock bag
-Whole blood, serum and urine specimen

2. Packing procedure

-When packing the shippers, use gloves to handle the dry ice to avoid burning the hands. Glasses or an eye shield should also be worn if the dry ice cakes are to be broken into small pieces. Dry ice will be used to pack the urine samples. Frozen ice packs will be used to pack the blood tubes.

-Place the specimens from each participant in the specimen boxes provided (white cardboard freezer boxes). Place each of these boxes inside one of the zip-lock bags provided.

-Pack the boxes in the bottom of the shipper. If necessary, use sheets of bubble-pack packing material to ensure the specimens vertical position. Put one layer of bubble-pack on top.

-Fill the shipper with dry ice (probably will hold 10-12 lbs) for the urine samples or with several of the frozen ice packs for the blood samples.

-Place more bubble material to even the top and place the polyfoam lid on top of the shipper.

-Insert the completed 'Specimen Shipping List' in a 12"x12" Zip-lock bag and secure to the top of the polyfoam lid with filament tape. (Remember to photocopy 2 copies of the 'Specimen Shipping List'. Keep one copy for your records and mail the other copy in a separate envelope to the following address:

SEE NOTE BELOW

Charles Dodson Mailstop F25
Chamblee Bldg. 17, Loading Dock
Centers for Disease Control
1600 Clifton Road N.E.
Atlanta, GA 30333

-Secure the outer cardboard lid on the shipper with filament tape.

3. Shipping procedure. SEE NOTE BELOW

-Cover or remove previous address labels on all shippers.

-Label each shipper with the following:

Preaddressed, shipping label with the following address:

Charles Dodson
Chamblee Bldg. 17, Loading Dock
Centers for Disease Control
4770 Buford Highway
Chamblee, GA 30341

-HUMAN BLOOD label
-DRY ICE label for shipper with the URINE specimens - fill in the spaces with the amount of dry ice

-REFRIGERATE-DO NOT FREEZE label for the BLOOD specimens
-GENERAL DIAGNOSTIC SPECIMENS - NON-INFECTIOUS label

If 'FEDERAL EXPRESS' is being used as the carrier, call their office at 1-800-238-5355 to arrange for pick-up. Telephone the laboratory at CDC the day the shipment is mailed at (404) 488-4305 and speak with Charles Dodson.

NOTE: Any correspondence sent through the postal service will only be delivered to the Clifton Road address and forwarded from there to the Chamblee facility. Federal Express delivers to the actual physical address zip-code, therefore use the Chamblee address for any shipments by FedEx.

V. SPECIMEN TESTS

A. URINE TESTS

TEST NAME	ABBREVIATION
Creatinine	CREAT
Mercury	HG
Metals	
Arsenic	AS
Cadmium	CD
Chromium	CR
Nickel	NI

B. WHOLE BLOOD TESTS

TEST NAME	ABBREVIATION
Lead	PB
Mercury	HG

AMERICAN SAMOA METAL EXPOSURE STUDY
STUDY # 92-0017
URINE COLLECTION AND PROCESSING PROTOCOL
|
URINE SAMPLE (15 mL minimum)
|
COLLECTION CONTAINER LABELED
"URINE CONTAINER"
|
ALIQUOT IN THE ORDER GIVEN INTO
DESIGNATED TUBES

U1 = Unpreserved urine
T1 & T2 = Preserved urine

PRIORITY	TUBE TYPE	ALIQUOT	URINE VOLUME	COMMENTS
1.	Orange cap conical tube	T1	Add to 10 mL line	Mix 5-10 times to dissolve preservative. Label for URINE MERCURY. Store at -20°C.
2.	Blue cap conical tube	T2	Add to 10 mL line	Add 100 uL concentrated nitric acid, mix 5 times. Label for URINE METALS. Store at -20°C.
3.	White cap plastic tube	U1	1-5 mL	Label for URINE CREAT. Store at -20°C.

NOTE: UNIVERSAL PRECAUTIONS SHOULD BE OBSERVED AT ALL TIMES WHEN COLLECTING AND HANDLING BODILY FLUIDS AS OUTLINED BY CDC. REFER TO MMWR VOLUME 36/NO. 2S, A COPY OF WHICH WILL BE AVAILABLE ON SITE.

A URINE SPECIFIC GRAVITY SHOULD BE DONE ON ALL URINES AFTER THE ABOVE ALIQUOTS HAVE BEE COLLECTED. THE SAMPLE SHOULD BE TAKEN WITH A PLASTIC PIPET FROM THE URINE COLLECTION CUP

URINE SHOULD BE POURED FROM THE COLLECTION CUP INTO THE ABOVE TUBES WITHOUT USING A PIPET TO ELIMINATE CONTAMINATING THESE SAMPLES.

AMERICAN SAMOA METAL EXPOSURE STUDY
CASE 92-0017
WHOLE BLOOD COLLECTION AND PROCESSING PROTOCOL

WHOLE BLOOD

ONE 3 ML PURPLE TOP TUBE

TUBE TYPE	ALIQUOT	BLOOD VOLUME	COMMENTS
3 mL Purple top	B1	1.5 mL	Place label for BLOOD LEAD/MERCURY on all tubes. Store in the refrigerator.

NOTE: UNIVERSAL PRECAUTIONS SHOULD BE OBSERVED AT ALL TIMES WHEN COLLECTING AND HANDLING BODILY FLUIDS AS OUTLINED BY CDC. REFER TO MMWR VOLUME 36/NO. 2S, A COPY OF WHICH WILL BE AVAILABLE ON SITE.

Page 1 of ______

SPECIMEN INFORMATION SYSTEM

FORM 1 - AMERICAN SAMOA METALS EXPOSURE STUDY

SPECIMEN SHIPPING LIST

Case Number: 92-0017

Shipment Number: ______

Number Shippers (Boxes): ______

Type of Specimens: Number of Specimens:

Shipped By: ______

Signature: ______

Date shipped: ______

Received By: ______

Signature: ______

Date Received: ______

Specimen ID (Participant #)	Mark Tube or aliquot collected T1	T2	U1	B1	S.G.	Date Collected	Comments (specify deviations in collection, storage or shipment)
92-0017-0001							
92-0017-0002							
92-0017-0003							
92-0017-0004							
92-0017-0005							
92-0017-0006							
92-0017-0007							
92-0017-0008							
92-0017-0009							
92-0017-0010							
92-0017-0011							
92-0017-0012							
92-0017-0013							
92-0017-0014							
92-0017-0015							
92-0017-0016							
92-0017-0017							
92-0017-0018							
92-0017-0019							
92-0017-0020							

Specimen types: B = Whole Blood

NTIS PB95-182994
BIOLOGIC INDICATORS OF EXPOSURE TO HEAVY METALS IN FISH CONSUMERS

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